PROPOSED GEOTHERMAL LEASING
ENVIRONMENTAL ANALYSIS RECORD
OR-020-6-61

BURNS DISTRICT NON-COMPETITIVE
GEOTHERMAL APPLICATIONS
AND
BURNS BUTTE KGRA

Burns District
Bureau of Land Management
U. S. Department of the Interior

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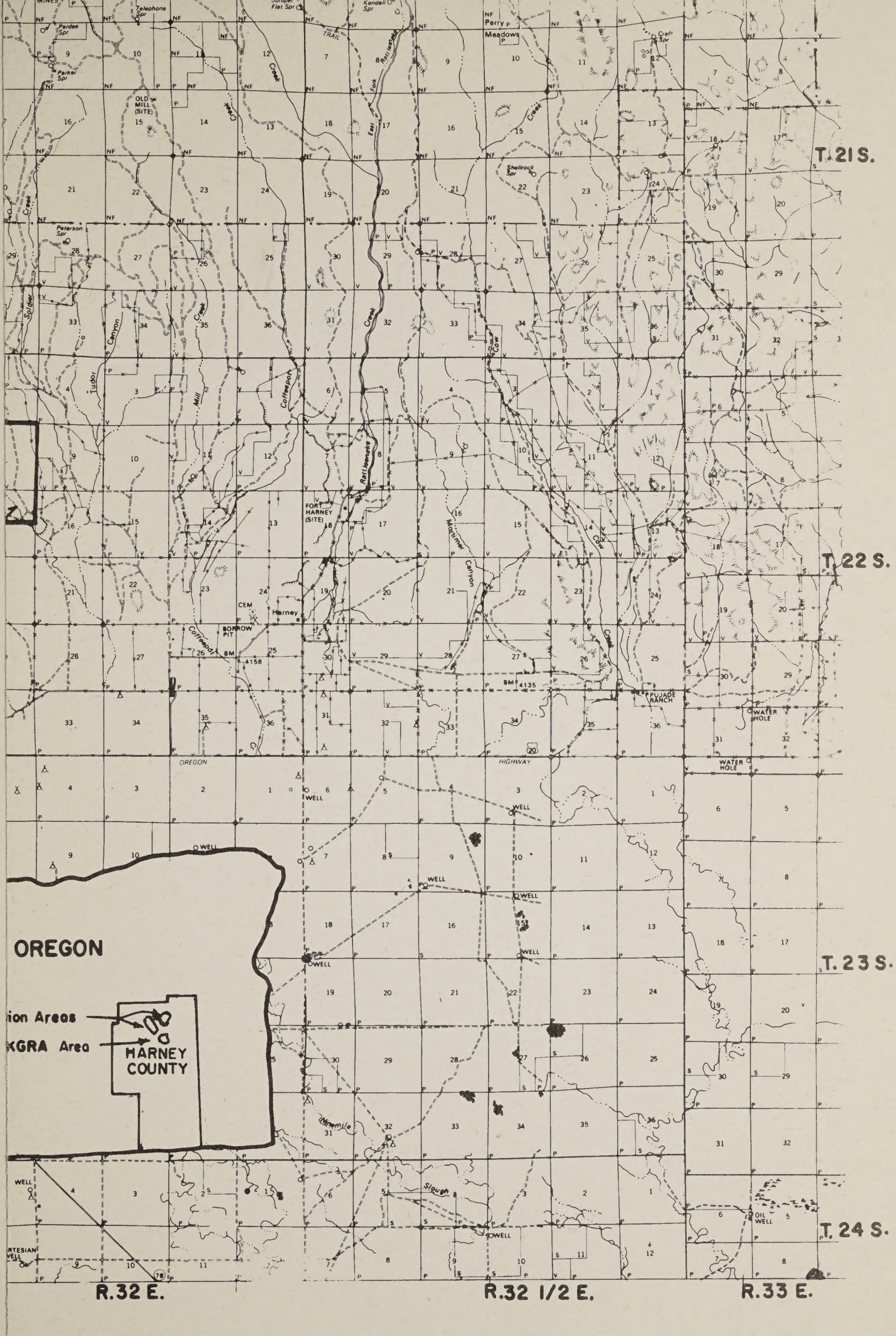

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OREGON
HARNEY COUNTY
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Perdee Spr
Parker Spr
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Peterson Spr
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OIL WELL
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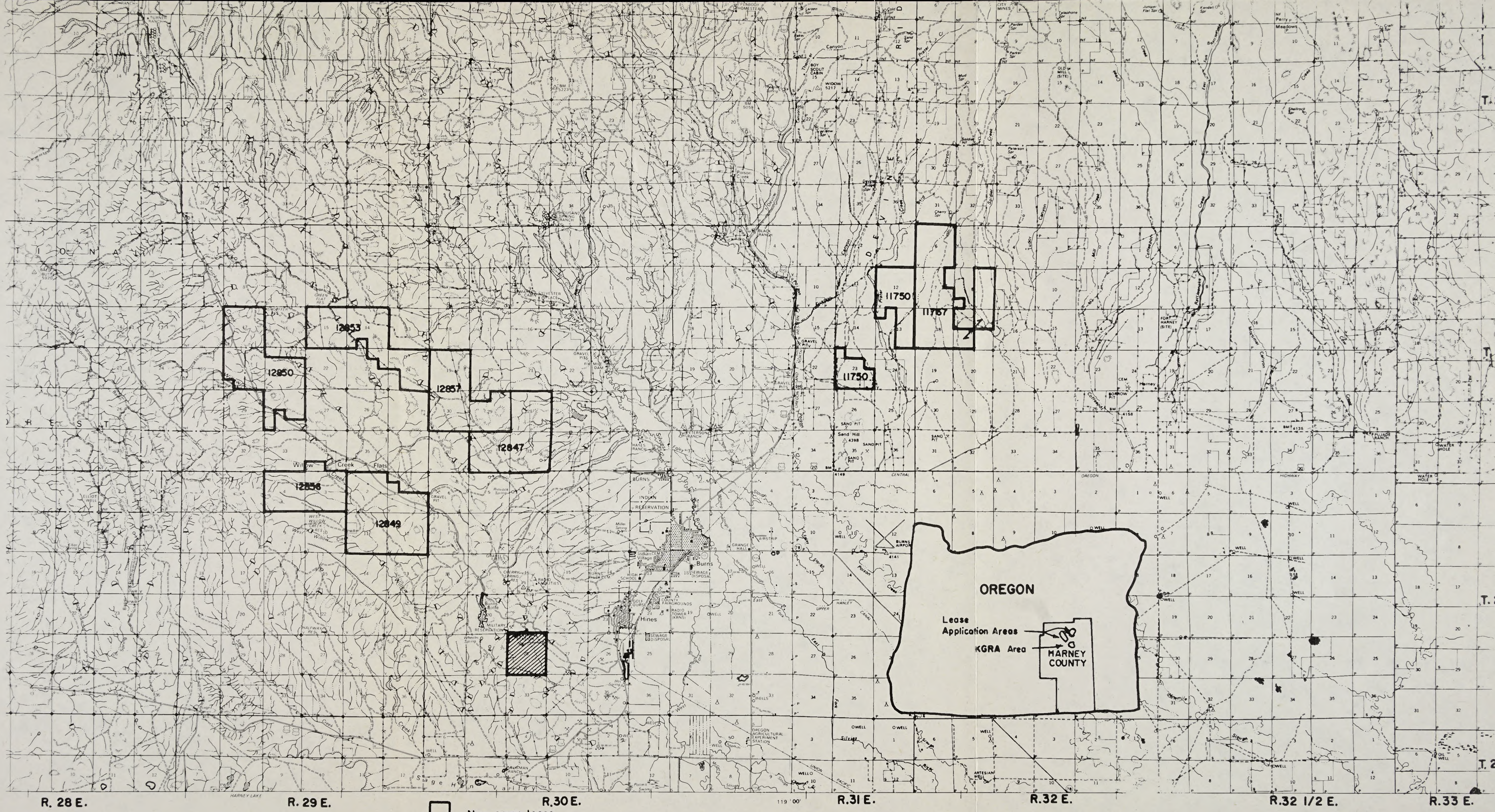
Ninemile Slough

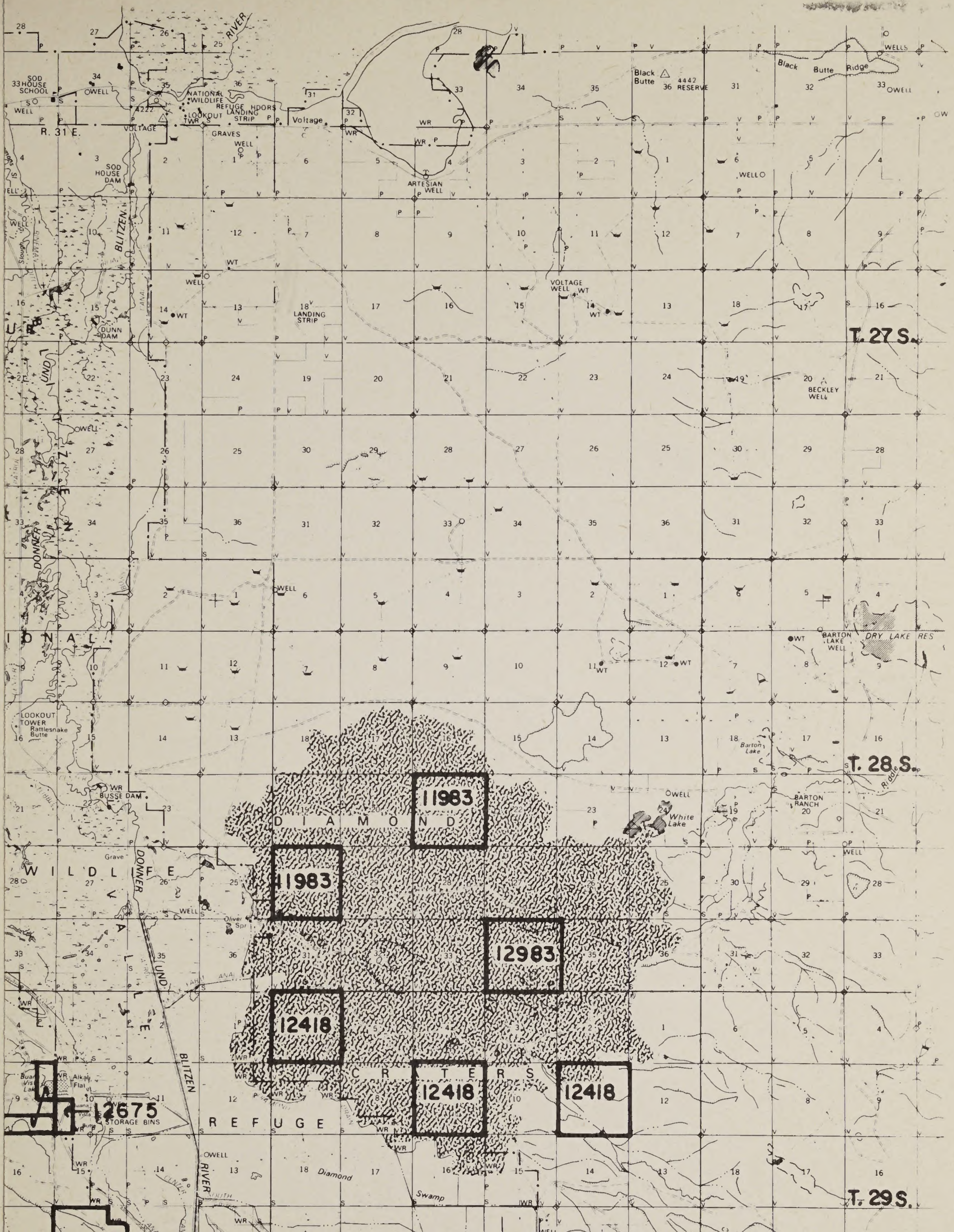
APPENDIX



Non-comp lease

KGRA

FIGURE 1a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LOOKOUT TWR
LANDING STRIP
Voltage
GRAVES WELL
SOD HOUSE DAM
ARTESIAN WELL
Black Butte
4442 RESERVE
Black Butte Ridge
WELLS
VOLTAGE WELL
LANDING STRIP
DUNN DAM
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T. 27 S.
BARTON LAKE WELL
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Diamond
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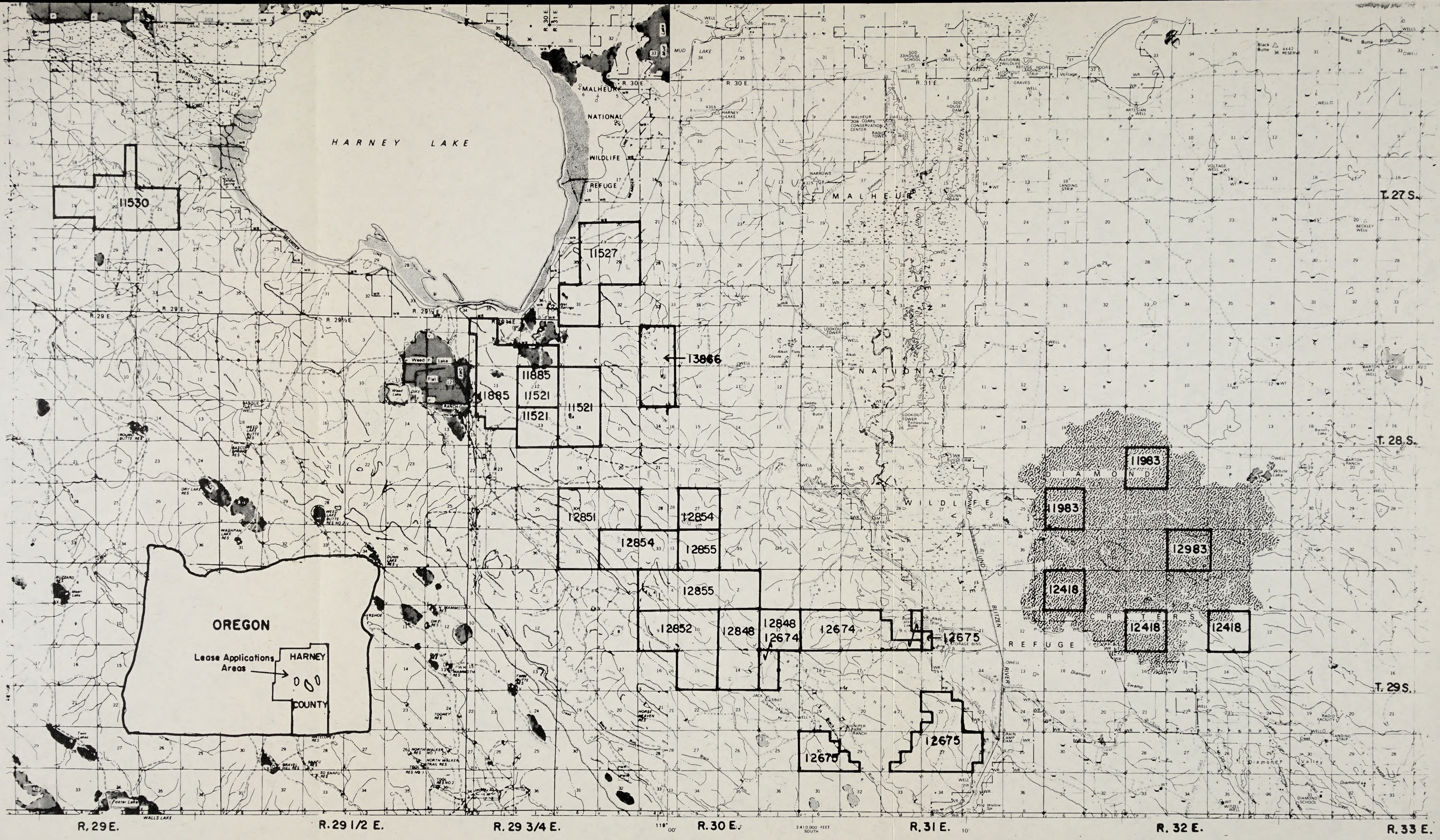
R. 31 E.
R. 32 E.
R. 33 E.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NATIONAL
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FIGURE Ib

I. DESCRIPTION OF THE PROPOSED ACTION

A. Proposed Action

1. Introduction

The proposed action is the leasing of National Resource lands and a small portion of National Forest lands for the rights of exploration and development of geothermal resources. This environmental analysis record (EAR) covers all of the non-competitive lease applications in the Burns district, a small portion of the Ochoco National Forest, and the Burns Butte Known Geothermal Resource Area covering 19,697.3 hect. (48,672 ac.) (Figure 1).

A Known Geothermal Resource Area (KGRA) is an area in which the geology, nearby discoveries, competitive interests, existence of hot springs, or other indicia would, in the opinion of the Secretary of the Interior, engender a belief that the prospects for extraction of geothermal resources may be economically feasible. A group, corporation or individual who is interested in obtaining a lease in a KGRA must competitively bid for the available leases. A non-competitive application for geothermal resources may be filed on lands not within a KGRA and open to leasing.

This environmental analysis record and technical report will describe the operational procedures in a geothermal exploration and development program and the administrative procedures to be followed in a leasing program. The environmental analysis record will also describe the setting in which leasing will occur, assess possible environmental impacts of the proposed action and recommendation measures to alleviate the impacts if the decision is to issue the leases.

Once all of these factors have been considered, the managing agencies will decide whether the issuance of geothermal leases would result in any significant environmental impacts. If the decision is that the issuance of the leases will have no significant environmental impact or it is not a major federal action, then positive measures will be recommended to reduce actual or potential adverse impacts. If significant impact seems likely, an Environmental Impact Statement (EIS) will be written. All of the factors would again be considered in the EIS, and a decision will be made whether to issue the leases, or in the case of the Burns Butte KGRA, the sale will be held. If impacts can be significantly reduced by mitigating measures, then the leases can be issued and the Burns Butte KGRA sale can be held.

The following is 1) an overview of the technical aspects of a geothermal operation, and 2) a summary of the administrative procedures that involve various Federal and State agencies before, during, and after a geothermal field is developed. But first, it is necessary to discuss what geothermal energy is and how it can be utilized.

2. Geothermal Energy

Geothermal energy is the natural heat of the earth. Observations and deductions from underground mines and well data indicate that temperatures increase downward to between 200°C (392°F) and 1000°C (1832°F) at the base of the earth's crust. The increase of heat with depth is called the geothermal gradient. Normally it would average about 1°F for every 33 meters (100') of depth. Some areas are discharging heat at rates of 10 to 1,000 times normal. These are areas of interest for development of geothermal energy.

It is thought that the natural heat of the earth is derived from radioactive decoy, friction (tidal and crustal plate motion) and possibly primeval heat. Most of this heat is too diffuse to utilize as a resource under present technology. Locally, however, it is concentrated in the crust by either 1) a deep-seated magma from which heat escapes via faults, or 2) a shallow magma or magma cooling chamber in areas of fairly recent volcanic activity (within the last few million years). Underground water is heated by these energy sources and rise toward the surface. In some places the hot water is trapped by overlying impervious rocks. In others it reaches the surface through faults in the form of hot springs, fumaroles, and geysers.

Table 1. Types of Geothermal Systems

	Temperature Characteristic
1. Hydrothermal convection system (heat content estimate - only to 3 km depth)	
a. vapor-dominated system	~ 240°C
b. Hot water system	
(1) high temperature	> 150°C
(2) intermediate	150°-90°C
(3) low temperature	< 90°C
2. Hot igneous system (heat content estimated 0-10 km depth)	
a. assumed part still molten	> 650°C
b. assumed not molten but very hot	< 650°C
3. Conduction dominated systems includes geopressured system (heat content estimated for 0-10 km depth)	15° to 300°C

Geothermal Systems and Utilizations

In essence, there are four types of geothermal systems: a vapor-dominated system, hot water system, geopressured reservoir system and a hot dry-rock system (Table 1).

The vapor-dominated system (dry steam) is believed to be a relatively rare system which yields steam and other gases with little or no water. When a well is drilled and the source is penetrated, the decrease in pressure superheats and dries the steam which then rises through the production well. This type of system has proved to be a valuable commercial resource in providing electrical generation. Commercial production wells can produce 22,727 to 136,364 Kg (50,000 to 300,000 lbs). of steam per hour. The steam is used to drive turbines to generate electricity. The only such vapor-dominated system in the U. S. is the Geysers area in California where presently 400 Mw are being produced. It is expected that 1200 Mw can be produced from this field by 1985 which would serve the needs of the entire city of San Francisco with a possible production potential of 4,000 Mw.

Another type of hydrothermal convection system is the hot water system. This system is a thermally driven convection system in which percolating water picks up heat from the heat source and moves upward in the system. Sometimes the hot water comes to the surface and is manifested as hot springs, geysers, and other thermal phenomena. But most of the thermal energy is stored in both rocks and in water and steam which fill the pore spaces in the rock. Tapping of the upwelling hot waters by wells result in a portion of the fluid, generally 15 to 25 percent, flashing to steam due to a pressure decrease. The steam may be separated from the hot water at the surface. Electric power generation from this type of system is being attained at Wairkei, New Zealand, Otaka, Japan, and Cerro Prieto, Mexico. The Cerro Prieto plant is located just south of the California border and the Imperial Valley uses this steam to produce 75 Mw of electricity. However, only a fraction of the usable energy is used in this system. One way to utilize more of the energy is using a binary production system which consists of closed circuit heat exchanger in which geothermal fluid is transferred to a low boiling point fluid, such as isobutane or freon, causing these fluids to boil. The resulting gaseous phase is used to propel the turbine, which in turn, powers the generator. The vapors condense upon cooling and are returned to the heat exchanger to be reheated.

Downhole generators are another possible method of utilizing the hot water system but it is still in the experimental stage like the binary production system. In a downhole generator, a turbine is placed inside the production well. Clean water is injected into the geothermal well to the depth of the reservoir where it is heated, evaporated and the resulting steam drives the turbine.

One approach to utilize both the hot water and steam is presently under research at the Lawrence Livermore Laboratory in California. They are devising a total-flow impulse turbine which will be driven by both the hot water and steam.

Most of these projects are directed toward the production of electricity. Other projects will use steam and hot water for power generation and then use the remaining heat of the hot water for agricultural and space heating projects. Where the temperature of the geothermal fluid is not sufficient to permit generation of electrical power, other commercial uses like those shown in Figure 2 may be possible.

Hot, dry rock systems (category 2, Table 1) consist of impermeable rocks overlying a local heat source such as a magma chamber. Such a magma chamber may be located under Burns Butte or Diamond Craters where molten rock (magma) which produced the volcanic rock may be still hot enough and shallow enough to be reached by drilling methods. However, to produce steam, water would have to be introduced into the hot dry rocks where it could flash into steam. More research is needed to develop this type of system into a workable system.

Geopressured reservoir systems (category 3, Table 1) consist of highly porous sands saturated with brines of high temperature. They are located principally along the Louisiana Coast and offshore Texas. These zones are thought to occur as a result of normal heat flow being trapped under compacted layers of clay which serve as a insulating layer. The liquid in the trapped sand below the clay layer results from water being forced down through the clay layer by intense pressure from above. These geopressured zones are found at depths of 1981 to 3048 meters (65,000 to 10,000 feet). Large amounts of methane gas coexist with the geothermal fluids and may be used commercially as a by-product. However, difficult technical and economic problems must be solved before this system may prove useful.

Figure 2. THE APPROXIMATE REQUIRED TEMPERATURE OF GEOTHERMAL FLUIDS FOR COMMERCIAL PURPOSES

°F	°C	
392	200	
374	190	
356 350	180	Evaporation of Highly Conc. Solutions Refrigeration by Ammonia Absorption Digestion in Paper Pulp, Kraft
338	170	Heavy Water via Hydrog. Sulphide Proc. Drying of Diatomaceous Earth
320	160	Drying of Fish Meal Drying of Timber
302	150	Alumina via Bayers Proc.
284	140	Drying Farm Products at High Rates Canning of Food
266	130	Evaporation in Sugar Refining Extraction of Salts by Evaporation and Crystalisation
248	120	Fresh Water by Distillation Most Multiple Effect Evaporations, Concentr. of Saline Sol. Refrigeration by Medium Temperatures
230	110	Drying and Curing of Light Aggreg. Cement Slabs
212 204	100	Drying of Organic Materials, Seaweeds, Grass, Vegetables, etc. Washing and Drying of Wool
194 183	90	Drying of Stock-Fish Intens De-Icing Operations
176	80	Space Heating Greenhouses by Space Heating
162 158	70	Refrigeration by Low Temperature
140	60	Animal Husbandry Greenhouses by Combined Space and Hotbed Heating
122	50	Mushroom Growing Balneological Baths
104	40	Soil Warming
86	30	Swimming Pools, Biodegratation, Fermentations Warm Water for Year Around Mining in Cold Climates De-Icing
68	20	Hatching of Fish; Fish Farmi

Saturated Steam

Water

Temp. Range of Conventional Power Production

3. Development of a Geothermal Field

The discovery and development of a geothermal field involves three successive stages--exploration, development and operation with each phase dependent upon successful results in the previous step. If and when the geothermal resource is depleted, site abandonment or close-out constitutes a fourth stage. In practice, one stage often blends into another as it would be common for exploration and development to be undertaken in one part of the field while the production phase is underway in another part of the field.

Exploration

The exploration stage includes all activities from the decision to explore for a geothermal field through the drilling of one or more deep exploratory wells. The purpose of an exploration program is to locate and define commercial geothermal reservoirs and to evaluate the impact of possible geothermal development upon the environment, including surface and subsurface resources and various land uses. Principal exploration activities include topographic and geologic mapping, geologic field examinations, ground and water temperature surveys, hydrogeochemical studies, geophysical surveys, and shallow (up to 153 m (500') deep) drilling. The purpose of the drilling is to take temperature measurements and sample the subsurface rocks. Airborne surveys, which include remote-sensing photography, may be employed in the earlier stages when large areas are being evaluated. But the hydrogeochemical, geological, and geophysical exploration techniques are employed to delineate smaller targets so that more expensive and detailed studies, such as shallow and deep drilling can extract specific detailed information in the more favorable areas.

The more common exploration techniques are the hydrogeochemical surveys and drilling shallow temperature gradient holes. Geochemical samples of water and gas of hot springs are taken to estimate the subsurface temperatures of geothermal fluids and to determine if there are any contaminants in the waters. Drilling shallow temperature gradient holes (up to 15.2 mm (6") in diameter) involves drilling with a truck mounted rig using existing roads or trails or on occasion some off-road vehicle use. In a few rare cases a narrow trail must be constructed and a drilling pad built. The drilling pad usually disturbs a 9 by 9 m (30' x 30') plot and a portable mud pit is used to contain the rock cuttings as the hole is drilled. Upon completion of the hole, a pipe (about 2.5 mm (1") in diameter) is placed in the hole, water is added to the

pipe, and the temperature is measured after one week (Figure 3). The temperature of the surrounding rock will heat the water in the pipe and is expected to increase with depth according to its regional temperature gradient. If the recorded temperature is above the average gradient for that type of rock and terrain, it is considered an anomaly which requires more detailed work and the next stage of exploration, a deep exploratory well.

The exploratory well involves a more intensive land disturbance usually 0.4 to 0.8 hectares (1 to 2 acres). A road is constructed for transporting heavy equipment and a drill pad is leveled and cleared of vegetation so that the drilling equipment, like the kind used in drilling oil and gas wells, may be set up on the site (Figure 4). The exploratory wells are usually drilled 1524 to 3048 m (5,000 to 10,000') deep to test thermal gradients, reservoir temperatures and volume of hot water and steam that can be extracted. A reserve pit of 926 to 9260 m^2 (1,000 to 10,000 $ft.^2$) and 1.8 to 2.4 m (6 to 8') deep is sometimes excavated to contain waste fluids and drill cuttings during drilling operations. The cuttings and solid components of the drilling mud are nontoxic and are disposed of in a site protected from erosion. Many additives are used to control the chemical and physical properties of the mud. Some of these additives or natural fluids may be toxic but proper disposal is necessary. The well casing is cemented in place and a blow-out preventer is installed to control sudden surges of pressure (Figure 5). A successful exploratory well will be tested for a few weeks. Testing involves flowing the well to the atmosphere and measuring the production at several different pressures to evaluate the geothermal reservoir. Several exploratory wells may be necessary but once the well(s) are completed the site is rehabilitated and revegetated if necessary.

Field Development

Field development involves a continuation of deep drilling to prove enough reserves to supply a generating plant or other use. The operations are much like exploration drilling, but more intensive in that 15 to 25 or more production wells per section are needed to sustain a generating plant. If the development wells provide sufficient energy for power generation, then a power plant, pipelines, and electric transmission lines must be constructed (Figure 6). Sometimes these development wells can be drilled from a single site when conditions permit. But the development wells are spaced so that the steam pipeline distance to the power plant is less than 1.6 km (1 mile). If the geothermal field is large, the

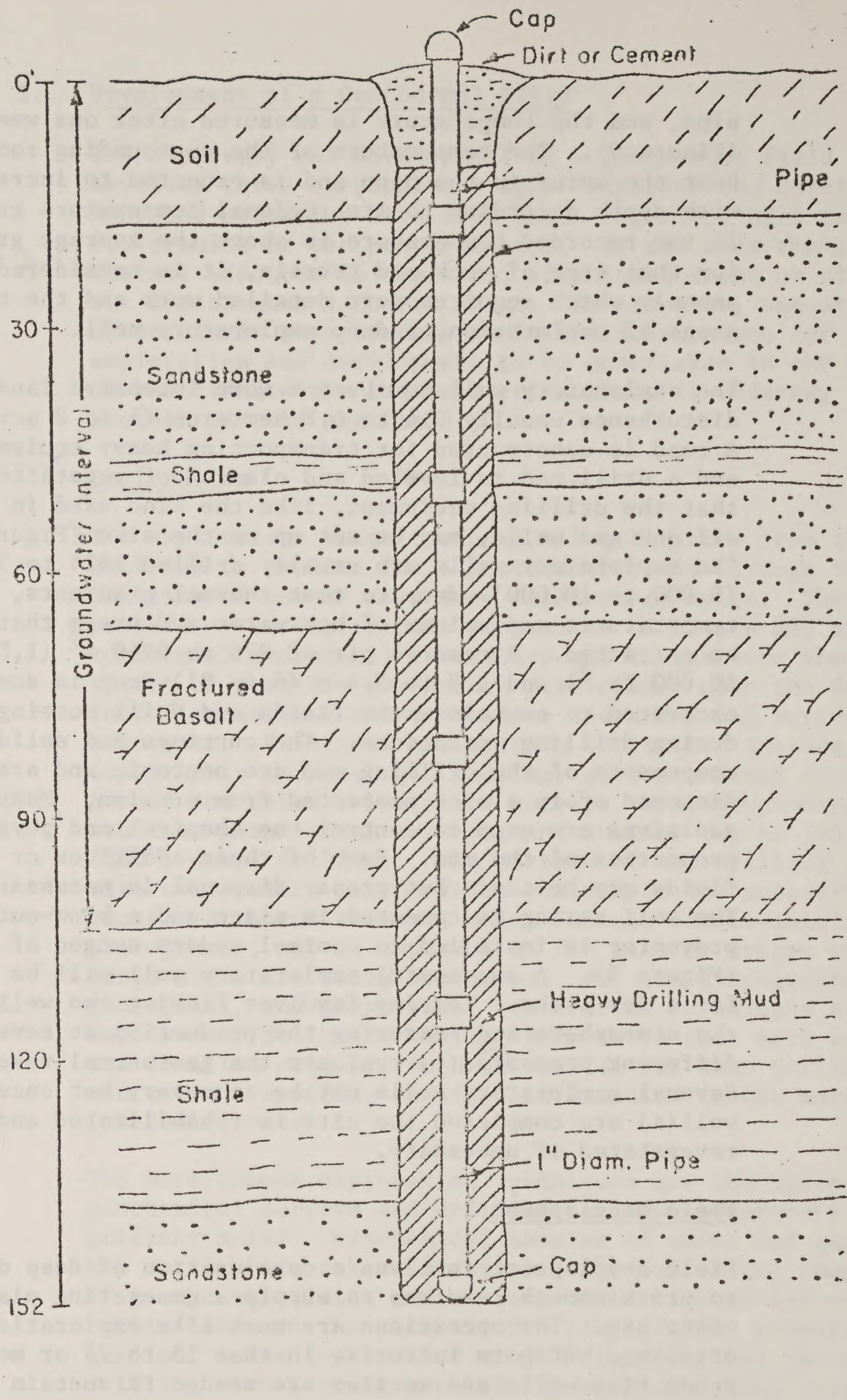

Figure 3. [illegible]PICAL TEMPERATURE OBSERVATIO[illegible] HOLE

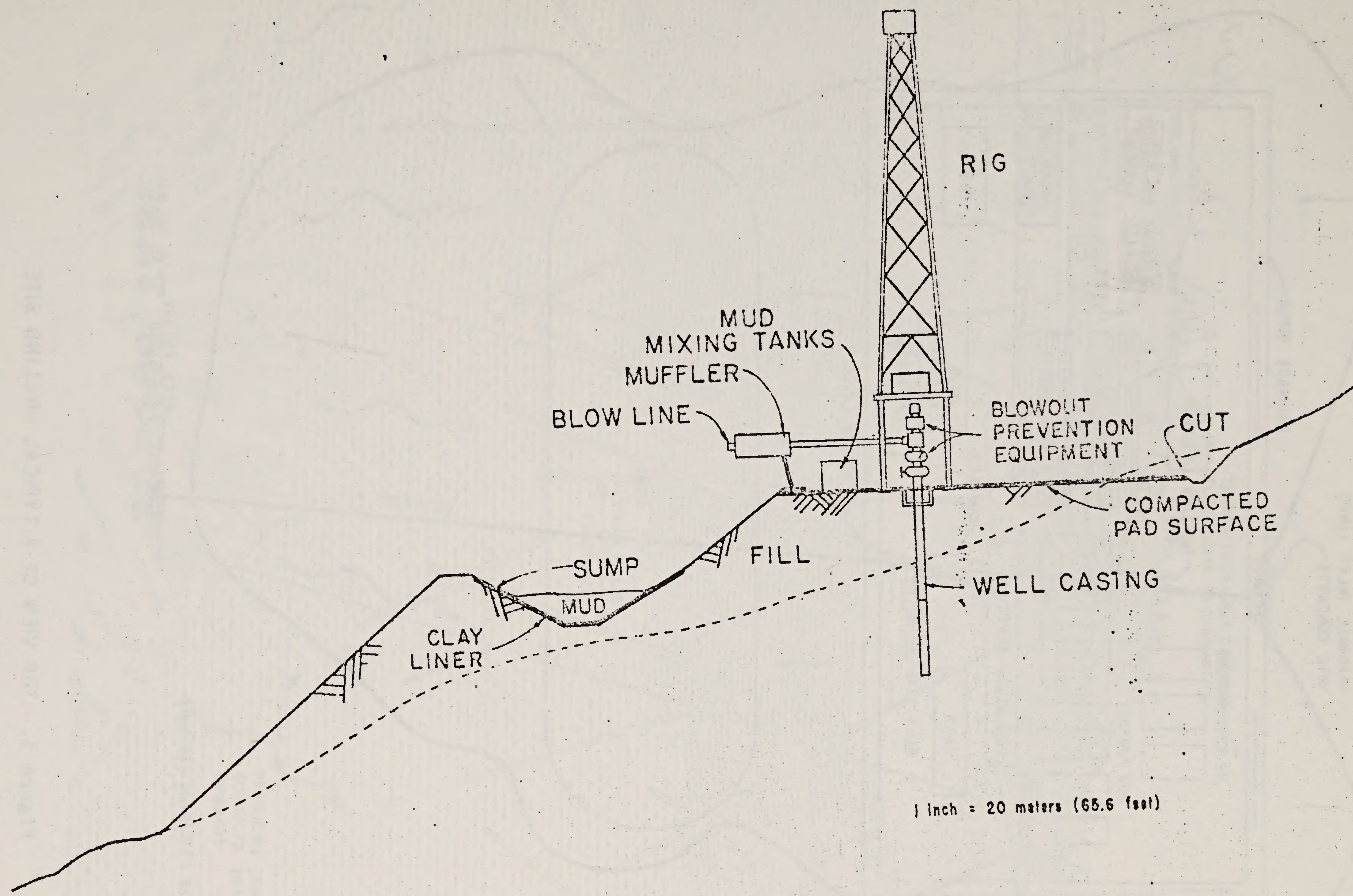

Figure 4. CROSS SECTION THROUGH TYPICAL DRILLING SITE

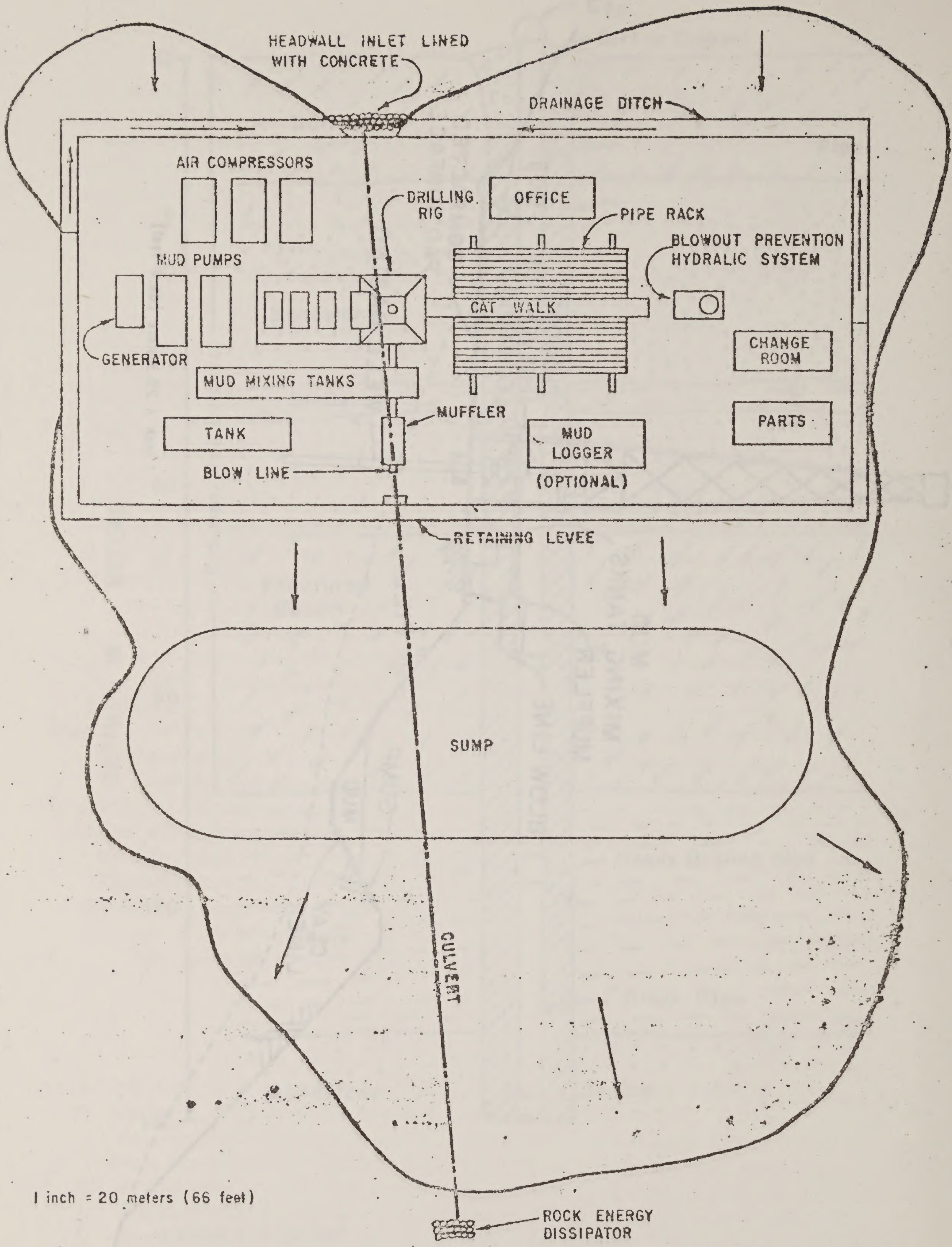

Figure 5. TOP VIEW OF A TYPICAL DRILLING SITE

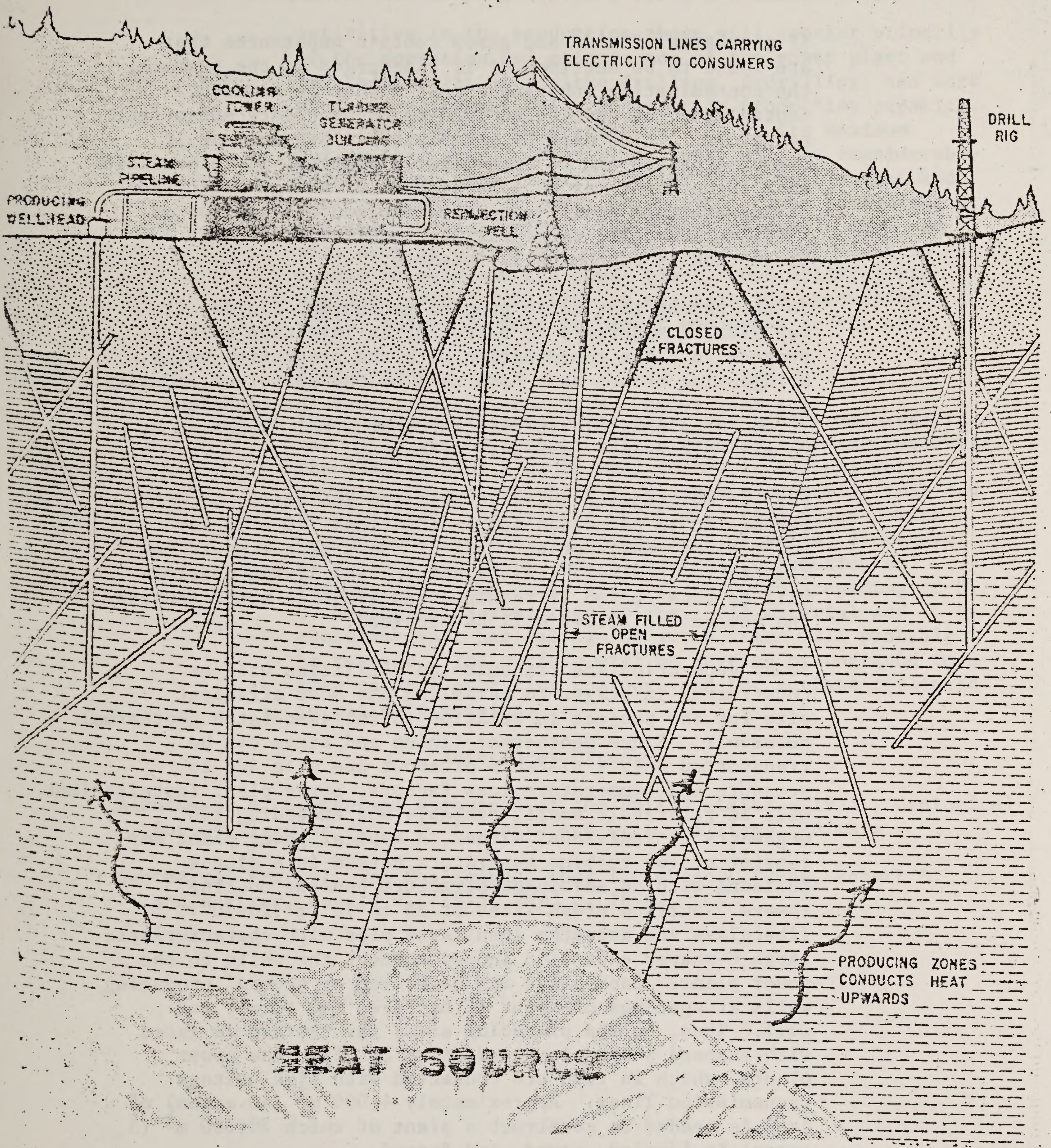

Figure 6. FACILITIES IN A GEOTHERMAL FIELD

development phase can continue for many years as new wells and power generating units are developed.

If geothermal fluids and gases contain substances that are found to be detrimental if discharged at the surface, the contaminating substances must either be removed, neutralized, or reinjected into the appropriate subsurface reservoir. If no harmful materials are present, or if these materials can be economically removed, it is possible that fresh water may be a by-product of energy production at a geothermal plant. Conservation and utilization of such demineralized water will be required where such production is economically feasible.

To the extent that wells produce geothermal fluids, it may also be necessary to carry out an injection well program in close coordination with the production wells. Reinjecting brines have been used by the petroleum industry for many years. With some adaptation of the technique, it would be possible to reinject geothermal fluids so as to maintain proper reservoir pressures.

For the development phase in drilling the wells, 40 - 60 persons would be needed and an additional 20 - 30 for power plant construction. All of these people would be temporary. However, limited service and living quarters will be constructed if required and adequate water sources and sewage facilities will be provided.

Power generation and transmission facilities will be constructed in stages to establish the most efficient size for the project in relation to the associated geothermal reservoir. Since geothermal fluids and steam can be transported only a distance of about one mile due to pressure and temperature loss factors, power plant installations will be relatively small, probably not exceeding 100 megawatts at individual sites. A typical power plant may consist of two turbine generators housed in a single building with an adjoining structure housing cooling towers. Surface steam lines of 25 to 76 Cm (10-30"), fiberglass and asbestos insultated pipe with characteristic large U-shaped expansion loops, connect the wells to the power plant. Each plant may be served by several producing wells at spacings of about 16 hectares (40 acres) per well. Thus, in the producing area, the terrain is laced with exposed steam pipes radiating out from the power plants, which in turn are connected with high voltage transmission lines. Approximately 4,000 m^2 (10 acres) of land is needed to construct a plant of which 20,000 m^2 (5 acres) is leveled, paved, and fenced.

Production

Activities in the production phase will consist primarily of the operation and maintenance of the power plant and related facilities and the drilling, redrilling, and work over of geothermal wells to maintain production capacity. Electrical energy generation will be at its maximum during this stage. Overall activity will be considerably reduced over that required during field development and the construction of power generation, power transmission, and related facilities. The number of people employed will drop as only 5 persons for each 110 MWe plant is needed to maintain the power plant. One drilling rig would be needed full time to maintain the production wells, adding 20 more permanent employees to the area.

Abandonment

The abandonment takes place after the geothermal resources can no longer be economically extracted from the reservoir. The knowledge of a geothermal reservoir has not yet advanced to a stage where a reasonable economic limit can be predicted. Activities which will take place during abandonment include: 1) abandonment of wells, 2) removal of surface equipment, and 3) surface reclamation and restoration. The wells will be abandoned according to U. S. Geological Survey regulations. All material and equipment that has salvage or scrap value will probably be removed. The surface will be leveled or regraded to a more natural appearing contour, and the surface replanted to mitigate erosion.

References Cited

Assessment of Geothermal Resources of the United States - 1975. Geological Survey Circular 726. D. E. White and D. L. Williams, Editors.

Geothermal Energy: The Challenges that lie ahead. Fuchs, Robert L. and Huttrer, Gerald W., 1975, EM/J p. 78-82.

4. Administrative Procedures

Before we discuss what administrative procedures are involved, it is necessary to examine roles that the Bureau of Land Management and the U. S. Geological Survey have in geothermal leasing program.

The Bureau of Land Management administers federal laws and regulations pertaining to mineral resources on lands under its primary jurisdiction (i.e., national resource lands) and those withdrawn for other agencies, and on private lands when the government owns the subsurface mineral rights. BLM, in consultation with the U. S. Geological Survey, and any other federal agency with surface management jurisdiction over lands in the area, determines whether and under what conditions federal geothermal leases will be issued.

After the lease is issued on lands administered by BLM, the Geological Survey oversees the geothermal activities including responsibility for maintaining and providing engineering, geological, geophysical, economic and other technical expertise to assure compliance with applicable laws, regulations and Interior Department objectives. They also ensure that the operator complies with any surface stipulations that the BLM has written into the lease. For a comprehensive view of the administrative procedures involved in geothermal leasing program, see Figure 7.

BLM's land use planning process constrains and guides oil and gas leasing on national resource lands. Geothermal development is one of many possible land uses considered in the Bureau's planning system. Once the existing resources have been inventoried in the Unit Resource Analysis and after the public has had an opportunity to contribute ideas and suggestions on how the land should be managed, BLM develops a Management Framework Plan, which indicates how land uses in the planning area will be coordinated and identifies constraints and parameters for future activities in the area. Management Framework Plans have been prepared for all areas prospectively valuable for geothermal energy in eastern Oregon. Since land use planning is a dynamic process, the Management Framework Plans are revised and updated as the need arises.

Once land use plans have been developed, BLM prepares an Environmental Analysis Record (EAR) on the geothermal lease area. The Environmental Analysis Record describes the setting in which the action is to occur, possible

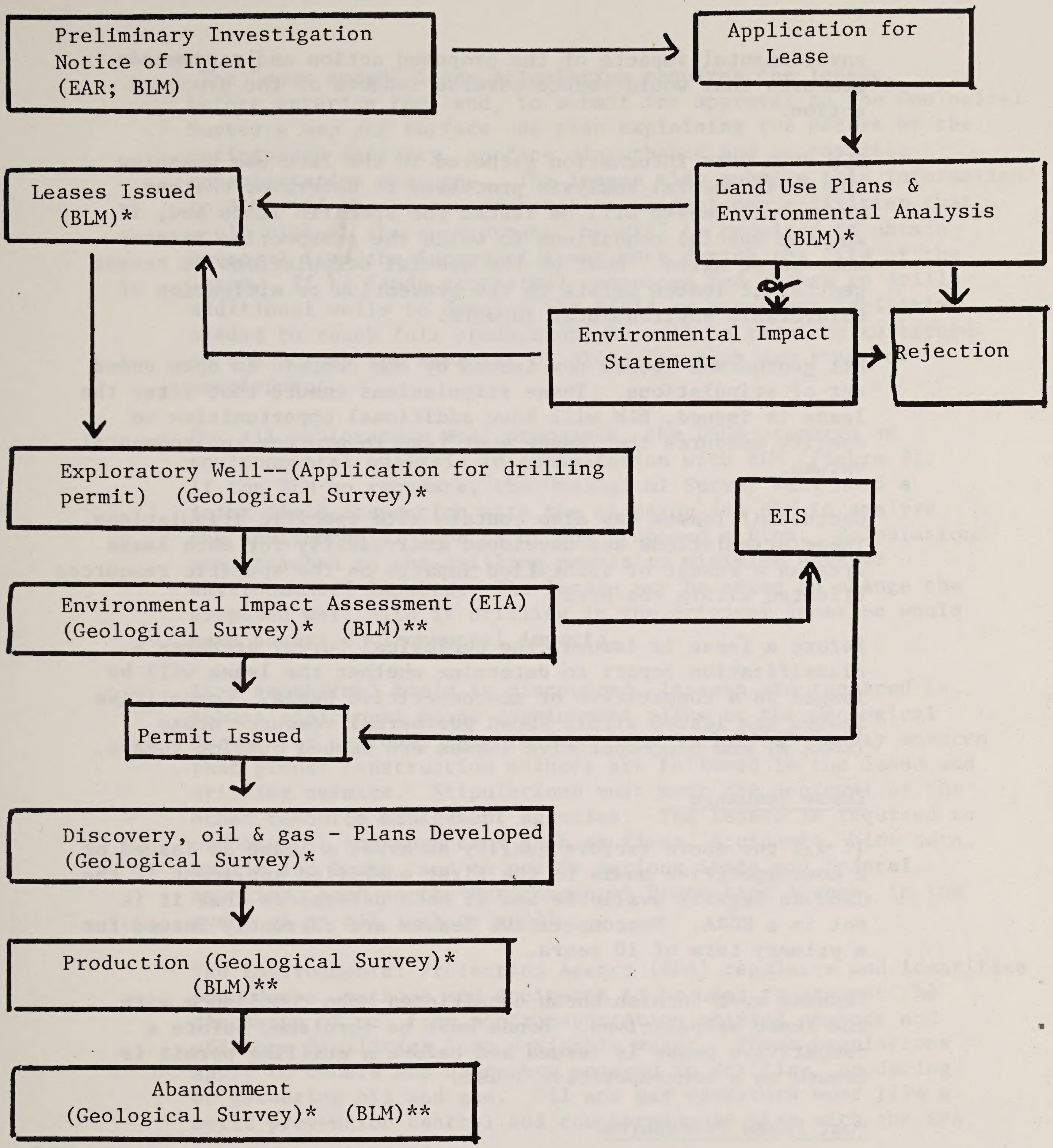

Figure 7. Administrative Procedures in Geothermal Leasing Program

* primary responsibility

** secondary or advisory responsibility

environmental impacts of the proposed action and recommends measures that would reduce adverse impacts of the proposed action.

BLM then uses information gathered in the land use planning and environmental analysis processes to determine whether geothermal leases will be issued for specific lands and, if so, the special conditions to which the prospective lessees must first agree. Most of the special stipulations in recent geothermal leases relate to the prevention or mitigation of unfavorable environmental impacts.

All geothermal leases now issued by BLM contain an open ended set of stipulations. These stipulations ensure that after the lease is issued, BLM will have additional opportunities to specify measures the lessee must take to protect environmental values.

Geothermal leases may also contain site specific stipulations. These stipulations are developed individually for each lease area as a result of identified impacts on the specific resources affected within the area.

Before a lease is issued, the Geological Survey prepares a classification report to determine whether the lease will be issued on a competitive or noncompetitive basis. Competitive leases are issued within known geothermal resource areas (KGRA's) and noncompetitive leases are issued outside KGRA's.

Lease Issuance

If all the above factors qualify an area, a lease is issued on a noncompetitive basis to the first qualified applicant if the land is legally available and if USGS determines that it is not in a KGRA. Noncompetitive leases are currently issued for a primary term of 10 years.

Lessees must furnish bonds conditioned upon compliance with the lease stipulations. Bonds must be furnished before a competitive lease is issued and before a drilling permit is issued on a noncompetitive lease.

Post Lease Procedures

During the term of the lease, the Geological Survey supervises operations of the lessee in that portion of the lease tract within that which has been legally defined as the "area of operations". Each "area of operations" is specifically defined in the lessee's drilling permit application and generally refers to the area of direct exploratory activity. BLM recommends surface protection and rehabilitation measures before the Geological Survey acts on the drilling permit. BLM supervises the activities outside the area of operations.

The "open ended" lease stipulation requires the lessee, before entering the land, to submit for approval to the Geological Survey a map and surface use plan explaining the nature of the anticipated activity, surface disturbance and appropriate rehabilitation measures. The lessee also submits this information to BLM. If the lessee proposes to conduct any activities that would disturb the environment, he will be required to obtain approval from the Survey at least once during the life of the lease. If he finds geothermal resources and wishes to drill additional wells to develop the field or construct facilities needed to reach full production, he will be required to return to the Survey for approval of plans for each new stage of development.

For all exploratory well proposals, the USGS prepares an environmental analysis in consultation with BLM (Figure 7). If the BLM so requests, the Geological Survey will hold a joint field inspection with the operator and BLM to analyze the environmental impacts of the proposed action. Stipulations are attached to the drilling permit to minimize adverse environmental impacts. The lessee may be asked to change the proposed well site if drilling in the original location would have severe environmental impacts.

If a geothermal field is discovered, lessees are required to submit additional lease development plans to the Geological Survey for approval (Figure 7.). The Geological Survey ensures that proper construction methods are followed in the lease and drilling permits. Stipulations must meet the approval of the other resource management agencies. The lessee is required to prepare for contingencies such as fires, accidents, blow-outs, spills and leaks, and to notify various State and Federal agencies, such as the Environmental Protection Agency, in the event of an oil leak or spill.

The Environmental Protection Agency (EPA) regulates and identifies procedures, methods and equipment to be used to prevent the discharge of oil from nontransportation related onshore and offshore facilities into navigable water. These regulations apply to owners and operators engaged in drilling, producing or gathering oil and gas. Oil and gas operators must file a spill prevention control and countermeasure plan with the EPA.

State Requirements

Such an operation must meet not only Federal but State requirements. In Oregon, the State Department of Geology and Mineral Industries (DOGAMI) requires a permit for any drilling operation. The agency must also approve casing and cementing programs designed to prevent leakage of contaminating fluids, inspect blowout

prevention equipment, witness abandonment plugging and collect well records. In the event of a discovery, the Department's rules require uniform development, location and spacing of wells and regular reporting of storage and production.

The State Department of Environmental Quality (DEQ) may add conditions to the state drilling permit that enforce compliance with state air and water quality laws.

Before a drilling permit is issued, the application is reviewed by the Oregon Department of Environmental Quality (DEQ), the Water Resources Department, the Department of Fish and Wildlife and the Department of Land Conservation and Development (LCDC).

B. Alternatives to the Proposed Action

Alternative No. 1 - Decline to Lease

No description of this alternative is needed since use of the area will remain the same.

Alternative No. 2 - Leases a Portion of the Area

This alternative is the option of the District Manager to determine, based on analysis of the proposed action discussed herein and whatever public comment is received after distribution of the EAR, to decline to lease certain of the lands under application, but to proceed with leasing of other lands. No further discussion of this alternative is needed since impacts of leasing will be described under the proposed action and, for lands not leased, use of those areas will remain the same. The purpose of this alternative is to permit development of federal geothermal resources in areas where the environmental impacts of the action are not significant.

II. DESCRIPTION OF THE EXISTING ENVIRONMENT

A. Physiography

The lease area lies entirely within the High Lava Plains Province that is characterized by lava flows 1,067 to 1,829 km (3,500 to 6,000 feet) above sea level whose nearly uneroded surface carry few established streams. All of the drainage is into the closed Harney Basin. The nearly treeless, low valley bottoms and plateau areas support mainly sagebrush and bunch-grasses, whereas the elevated foothills are covered with scattered juniper.

B. Geology

The lease areas lie in the High Lava Plains, an uplifted region of young and faulted volcanic rocks with minor amounts of sedimentary rocks (Figures 8 a & b). The tertiary volcanic rocks are basalt and rhyodacite flows, ash-flow tuffs and tuffaceaus sediments.

Ash flow tuffs overlap the basaltic lavas which had spread laterally over several thousand square miles of ancestral Harney Basin. The welded ash flow tuff of the Double O Ranch is found in the Willow Creek, Prather Creek and South Harney Lake lease areas (Figures 8 a & b). Eruption of this tremendous volume of ash flows apparently permitted some crustal collapse into the evacuated magma chamber and this collapse is partly responsible for the development of the large structural depression of the Basin.

The structural pattern of this region is dominated by the major northwest trending Brothers fault zone. This zone is dominated by closely spaced en echelon normal faults of moderate to small displacement that localized many basaltic and rhyolitic vents. One such eruptive center is at Burns Butte, an area of silicic volcanic flows and associated pyroclastic material of Pliocene age. A supplemental geologic report written by the Geological Survey can be found in Appendix A..

The Diamond Craters area is an area which can be described as a small shield volcano which covers approximately a 3.6 km (6 mile) diameter area. Its origin is the result of a laccolith that intruded the earlier sediments and volcanics of the Danforth and Harney Formations possibly as recent as 1,000 years ago. It took several episodes of doming, eruptions, and collapse to produce the features that are visible today. Some of these features are shown in Figure 9.

The Central Crater complex is an area where much of the volcanic activity had occurred. Many volcanic episodes of doming then eruption of volcanic materials and subsequently collapse was responsible for its form and shape today. The Graben Dome is an unusual area in that the area bulged upward in a dome shape, but collapsed in a long linear shape when the lava erupted at lower elevations and drained away, thereby withdrawing support. Other craters such as Cloverleaf Crater, Keyhole Crater, and others show the same features.

Other craters such as Red Bomb, Big Bomb, and Litte Red Cone were formed by a build up of pyroclastic material such as cinder, lapilli, scoria, and bombs. The volcanic bombs have an interesting origin. These are composed of accretionary layers of black or reddish lava surrounding an angular rock fragment. These rock fragments were torn from the walls of the conduit and coated with lava and carried through the vent only to roll back into the vent in which they received another coating of lava.

Malheur Maar is an explosion crater formed by one or more gas eruptions or steam blasts. Very little or no magmatic material was erupted. The crater later then filled with water forming a lake. Many other features such as spatter cones, driblet spires, tumuli, and pahoehoe flows are well preserved in the area since little detail has been destroyed by weathering or erosion.

Economic Minerals

The lease areas have been classified by the U. S. Geological Survey as prospectively valuable for geothermal resources. The area also carries the same classification for oil and gas. A deep exploratory oil and gas well is planned to be drilled this fall or early next spring. Some information may be available from this well. Zeolitic minerals such as clinoptilolite and erionite have been found in the Danforth Formation south and east of Harney Lake.

Several cinder pits in the Diamond Craters area are used for road building and maintenance. Some of the lava rock with its platy structure has been stolen from Federal lands. The lava rock is being used as building and decorative stone. On Burns Butte, there are several pits where white pumice has been exposed and small quantities have been taken. The white pumice is used for decorative purposes such as landscaping around homes.

Geologic Hazards

Geologic hazards present in the lease area include land subsidence, earthquakes, floods, and volcanic activity. Although these

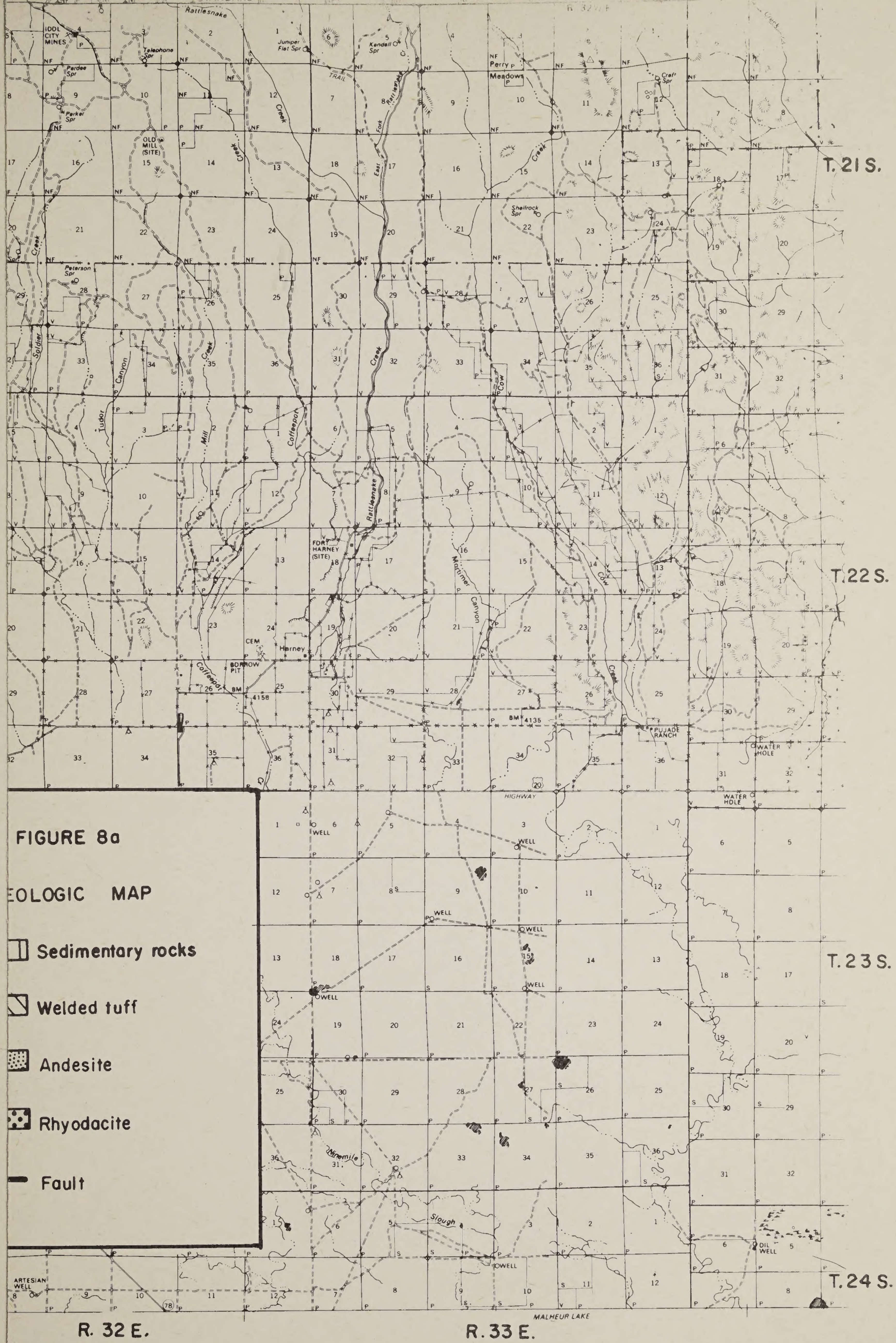
FIGURE 8a
EOLOGIC MAP
Sedimentary rocks
Welded tuff
Andesite
Rhyodacite
Fault
T. 21 S.
T. 22 S.
T. 23 S.
T. 24 S.
R. 32 E.
R. 33 E.
IDOL CITY MINES
Rattlesnake
Telephone Spr
Juniper Flat Spr
Kendall Spr
Perry
Meadows
Craft Spr
Perdee Spr
Parker Spr
TRAIL
Creek
East Fork Rattlesnake
OLD MILL (SITE)
Shellrock Spr
Peterson Spr
Soldier Creek
Tudor Canyon
Mill Creek
Coffeepot
Cow Creek
Rattlesnake Creek
FORT HARNEY (SITE)
Mortimer Canyon
CEM
Harney
BORROW PIT
BM 4158
BM 4135
PUJADE RANCH
WATER HOLE
HIGHWAY
WELL
Ninemile
Slough
ARTESIAN WELL
OIL WELL
MALHEUR LAKE

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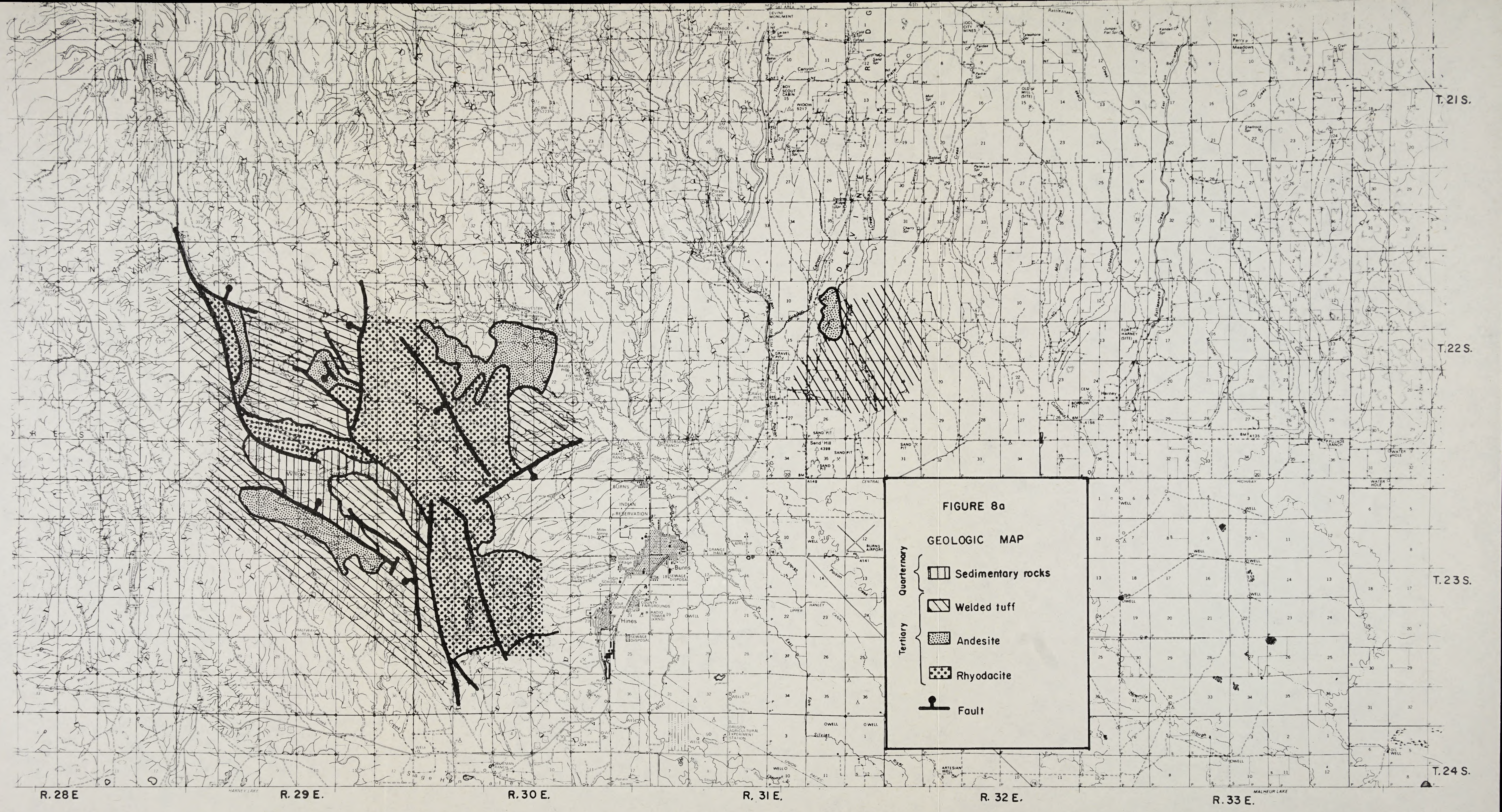
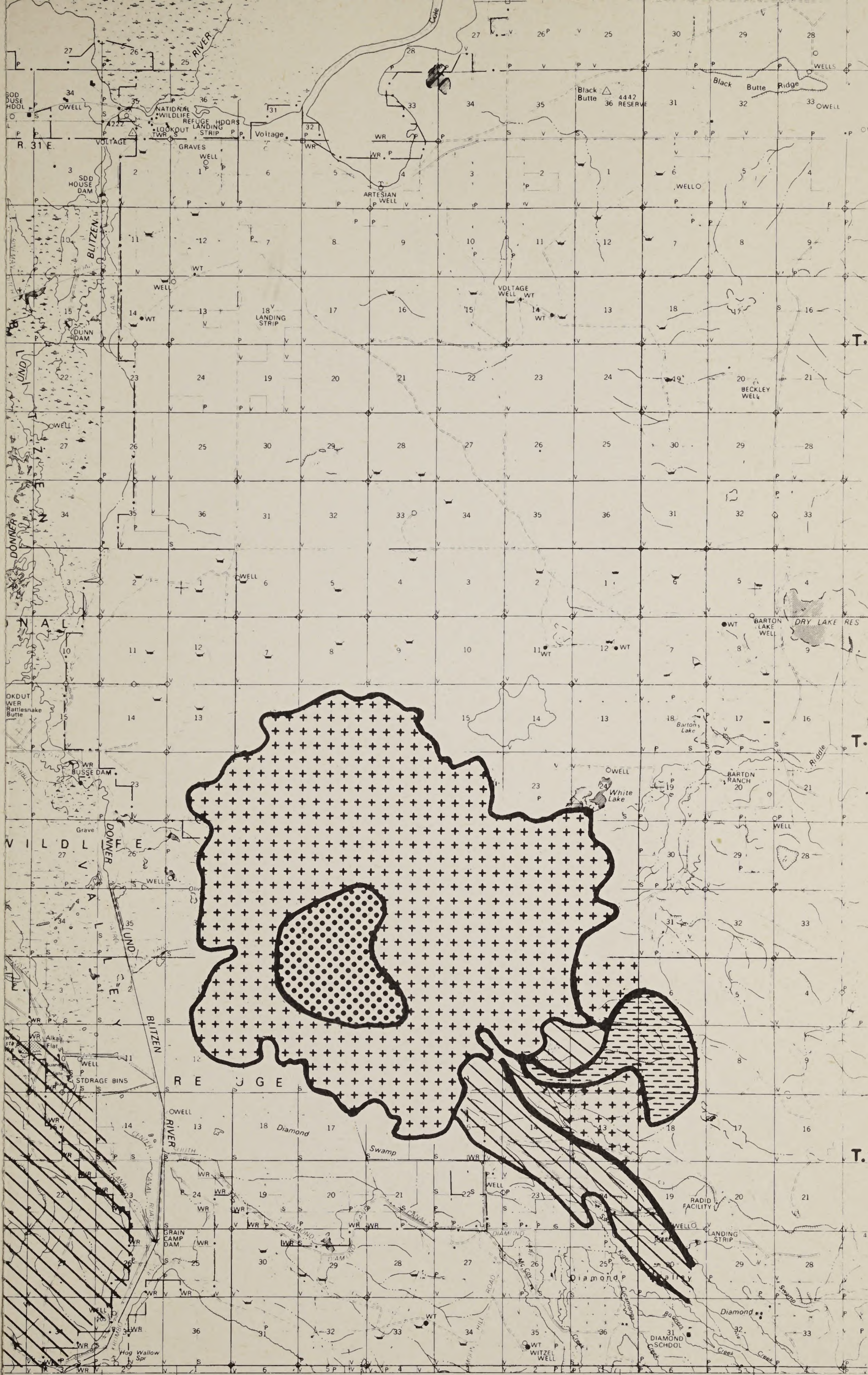


FIGURE 8a
GEOLOGIC MAP
Quaternary
Sedimentary rocks
Tertiary
Welded tuff
Andesite
Rhyodacite
Fault
T. 21 S.
T. 22 S.
T. 23 S.
T. 24 S.
R. 28 E
R. 29 E.
R. 30 E.
R. 31 E.
R. 32 E.
R. 33 E.
Burns
Hines



T.29S.
T.28S.
T.29S.
R.31E.
R.32E.
R.33E.
NATIONAL WILDLIFE REFUGE HDQRS
LANDING STRIP
LOOKOUT TWR
Voltage
GRAVES WELL
SOD HOUSE DAM
ARTESIAN WELL
Black Butte
4442 RESERVE
Black Butte Ridge
VOLTAGE WELL
LANDING STRIP
BECKLEY WELL
DUNN DAM
BARTON LAKE WELL
DRY LAKE RES
Barton Lake
BARTON RANCH
White Lake
BUSSE DAM
Rattlesnake Butte
STORAGE BINS
Alkali Flat
Diamond Swamp
GRAIN CAMP DAM
RADIO FACILITY
Diamond
DIAMOND SCHOOL
WITZEL WELL
Hog Wallow Spr
BLITZEN
DONNER
RIVER

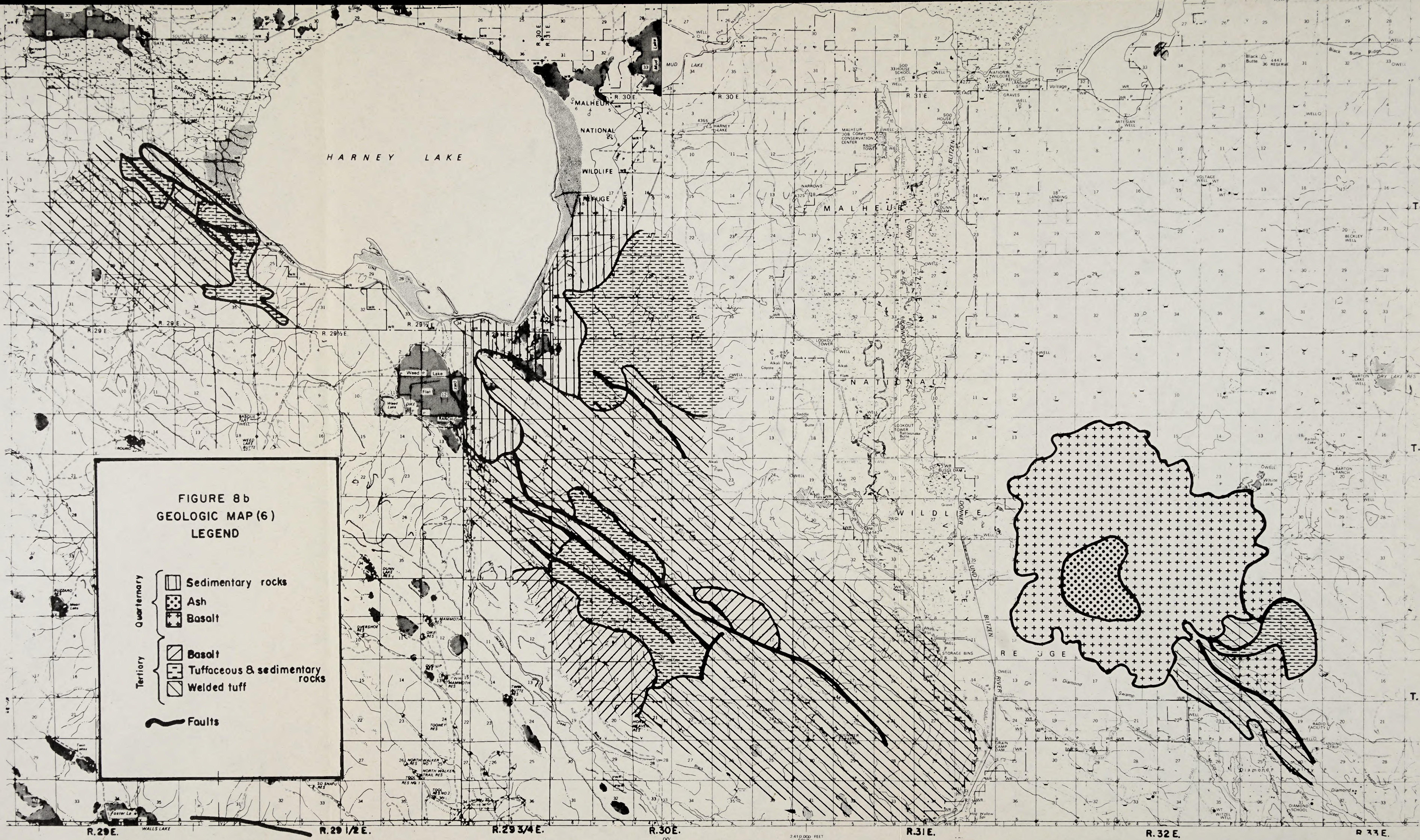
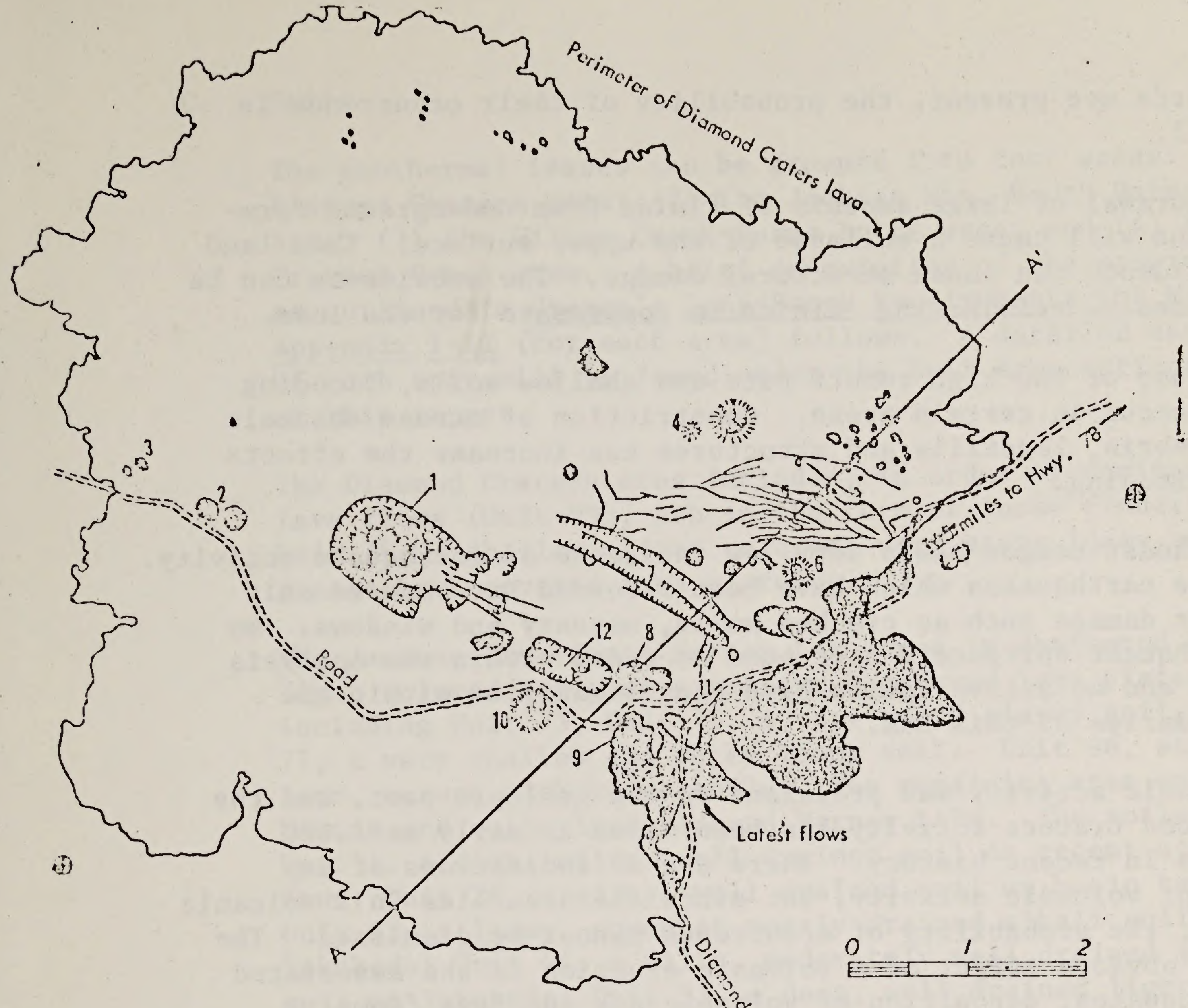


FIGURE 8b
GEOLOGIC MAP (6)
LEGEND
Quaternary
Sedimentary rocks
Ash
Basalt
Tertiary
Basalt
Tuffaceous & sedimentary rocks
Welded tuff
Faults
HARNEY LAKE
MALHEUR NATIONAL WILDLIFE REFUGE
R.29E.
R.29 1/2 E.
R.29 3/4 E.
R.30E.
R.31E.
R.32 E.
R.33 E.
T.29S.
T.28S.
T.29S.



Feature	Name		
1.	Central Crater Complex	7.	Graben Dome
2.	Twin Craters	8.	Keyhole Crater
3.	Malheur Maar	9.	Lava Pit Crater
4.	Little Red Cone	10.	Red Bomb Crater
5.	Northeast Dome	11.	Big Bomb Crater
6.	Cloverleaf Crater	12.	Oval Crater

Figure 9. GEOLOGIC FEATURES OF THE DIAMOND CRATERS AREA

hazards are present, the probability of their occurrence is small.

Withdrawal of large amounts of fluids from underground formations will cause a collapse of the upper surface. This land subsidence can cause structural damage. The subsidence can be avoided by reinjecting fluids to compensate for the loss.

Because of the high runoff rate and shallow soils, flooding may occur in certain areas. Constriction of stream channels by debris, landfills and structures can increase the effects of flooding.

Southeast Oregon has a very low incidence of earthquake activity. Those earthquakes which have been recorded have caused only minor damage such as cracked walls, masonry and windows. No earthquake epicenters have been recorded within the analysis area and no active faults have been identified within the boundaries of this EAR.

Volcanic activity was prevalent in the geologic past, and the Diamond Craters activity has been dated as early as 1,000 years in recent history. There are no indications of any recent volcanic activity, but since the area lies in a volcanic area, the probability of occurrence cannot be dismissed. The most obvious effect of a volcanic eruption is the associated earthquakes, deposition of volcanic ash and lava flows.

Selected References

Mineral and Water Resources of Oregon, 1969, Bull. 64, State of Oregon, Department of Geology and Mineral Industries.

Newton, V.C., 1976, An assessment of oil and gas leasing in the Prineville and Burns Management districts. Unpublished.

Peterson, N. V., and Groh, E. A., 1964, Diamond Craters, Oregon: The Ore Bin, v.26, no. 2, p. 17-34.

C. Soils

The geothermal leases can be grouped into four areas: (1) the Diamond Craters area; (2) the Jackass Mtn.-South Harney Lake area; (3) the Willow Creek-Burns Butte area; and (4) the Prather Creek area. A brief description of the mapping units as outlined in Oregon's Long-Range Requirements for Water, Appendix I-12 (for each area) follows. A detailed description of each unit will be found under the Soil Associations section of this report.

The Diamond Craters area includes, in order of dominance, bare lava flows (Unit 99), ash in the form of loose cinders, and Unit 75, a shallow, light colored, very stony loamy soil on grass-shrub covered lava plateaus.

The Jackass Mtn.-South Harney Lake area is dominated by shallow, light colored soils on grass-shrub covered lava plateaus, including Unit 75, Unit 76, a very stony clayey soil, and Unit 77, a very shallow and rocky loamy soil. Unit 96, steep rock land, occurs with these soils. The remaining area occurs as basins and valleylands around Harney Lake. The soils include: Unit 1, a deep, silty, well drained soil on recent alluvial fans; Unit 26, a silty, well drained soil on basin terraces; Unit 43, a loamy, somewhat poorly drained alkali soil on lakebeds; Unit 44, a silty, moderately well drained alkali soil on lakebeds; Unit 51, a deep, well drained light colored, wind blown sandy loam soil on older fans; and Unit 55, a shallow over hardpan, well drained, light colored loamy soil on older fans.

The Willow Creek-Burns Butte area is dominated by higher elevation grass-shrub covered plateaus with moderately dark colored soils: Unit 83, a shallow, very stony loamy to clayey soil, and Unit 84, a very shallow, rocky, loamy soil. Shallow, light colored soils on grass-shrub covered lava plateaus cover most of the remainder of the area, including Units 75, 76 and 96, and Unit S76, an extremely stony, clayey soil. Minor acreages of Units 55 (loamy) and 56 (clayey), light colored, well drained, shallow over hardpan soils also occur in the area.

The Prather Creek area occurs on grass-shrub covered lava plateaus, and contains one soil, Unit 77, a light colored, very shallow and rocky loamy soil.

Soil Associations

The soil associations in the geothermal leasing areas are grouped into three broad physiographic areas: (1) basins and valleylands; (2) lava plains and plateaus; and (3) higher elevation plateaus and mountainous uplands.

Legend for Soils Map(s)
"Figures 10a and 10b"

Soil Boundary and mapping unit symbol:

$\frac{75\text{-}96}{2}$ - mapping unit(s)
- slope group

Mapping Units

Acreage figures

Soil symbols in map delineations appear in order of dominance.

Two soils - 75-96 - in proportions of 70 and 30 percent

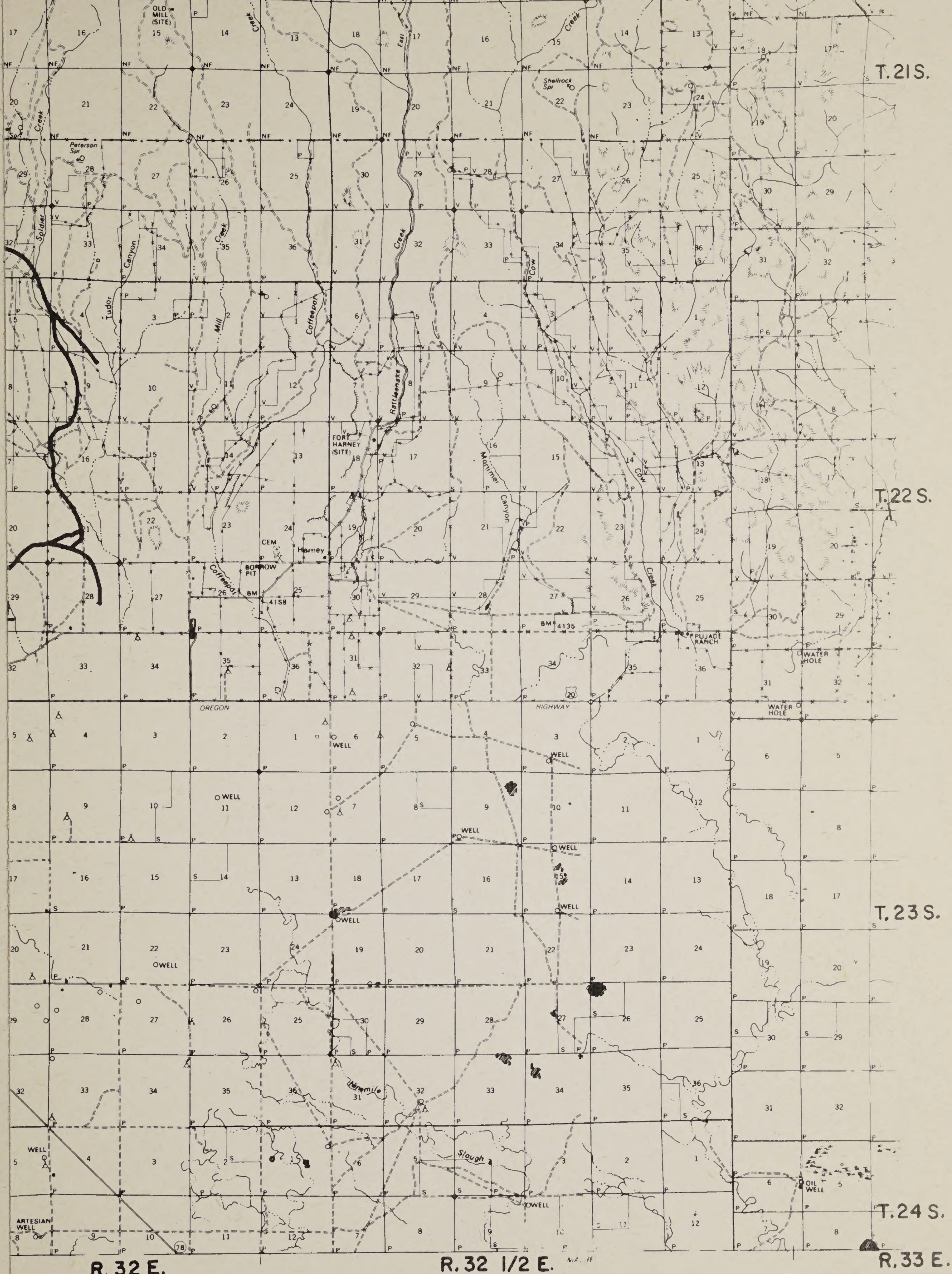
Three soils - 75-76-96 - in proportions of 50, 30, and 20 percent

Mapping units are described in the narrative.

Slope Groups

Symbol	Dominant Slope Range (percent)
1	0-3, nearly level
2	3-7, gently sloping
3	7-12, sloping
4	12-20, moderately steep
5	20-35, steep
6	35-60+, very steep

Scale: inch = 1 mile


OLD MILL (SITE)
T.21S.
T.22 S.
T.23 S.
T.24 S.
R.32 E.
R.32 1/2 E.
R.33 E.
Shellrock Spr
Peterson Spr
Soldier Creek
Tudor Canyon
Mill Creek
Coffeepot Creek
East Creek
Rattlesnake Creek
Cow Creek
Mortimer Canyon
FORT HARNEY (SITE)
CEM
Harney
BORROW PIT
BM 4158
BM 4135
PUJADE RANCH
WATER HOLE
OREGON HIGHWAY
WELL
ARTESIAN WELL
OIL WELL
Ninemile
Slough

Legend for Soils Map(s)
"Figures 10a and 10b"

Soil Boundary and mapping unit symbol:

$\frac{75\text{-}96}{2}$ - mapping unit(s) / - slope group

75-96 - mapping unit(s)
2 - slope group

Mapping Units

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Soil symbols in map delineations appear in order of dominance.

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Scale: inch = 1 mile

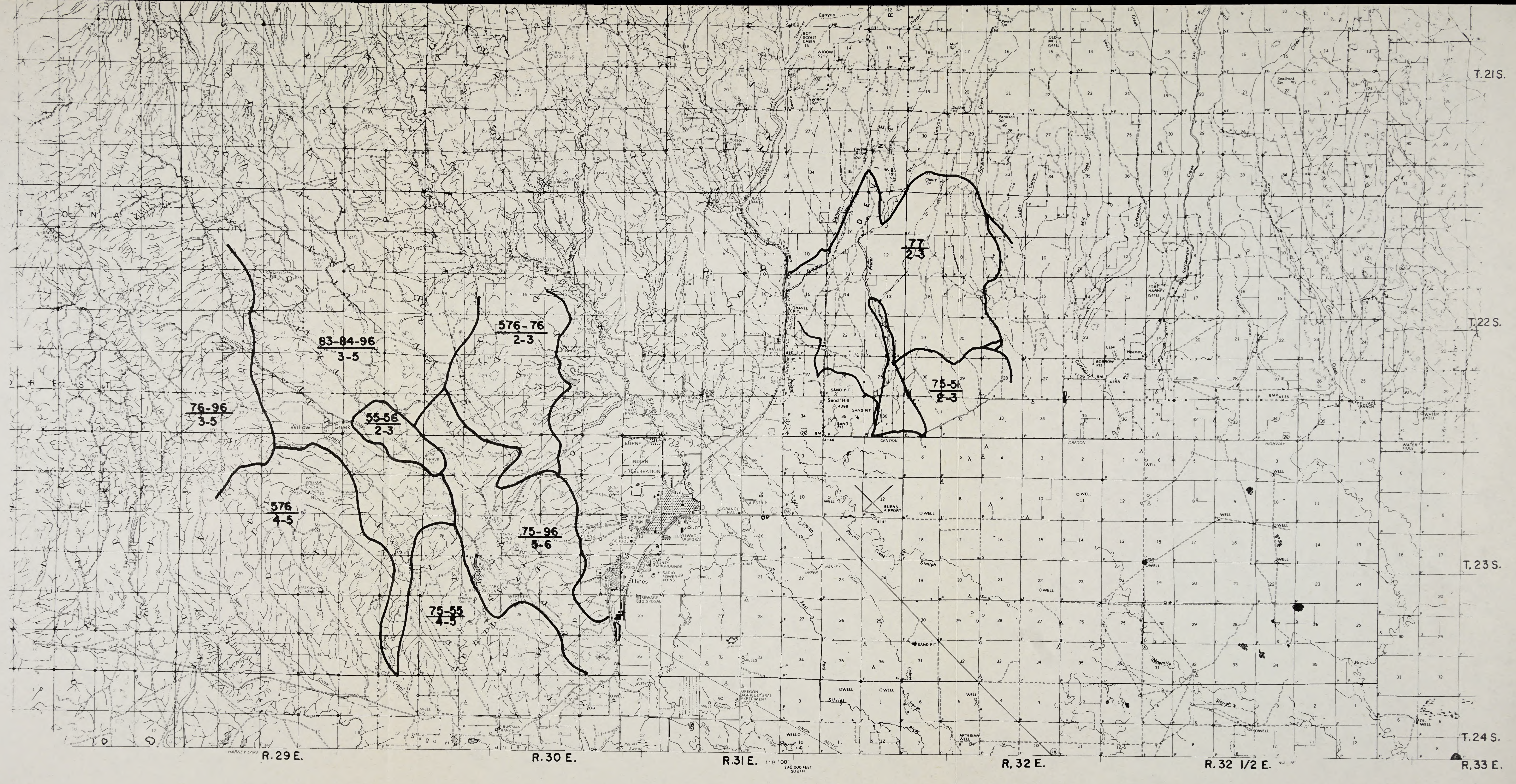
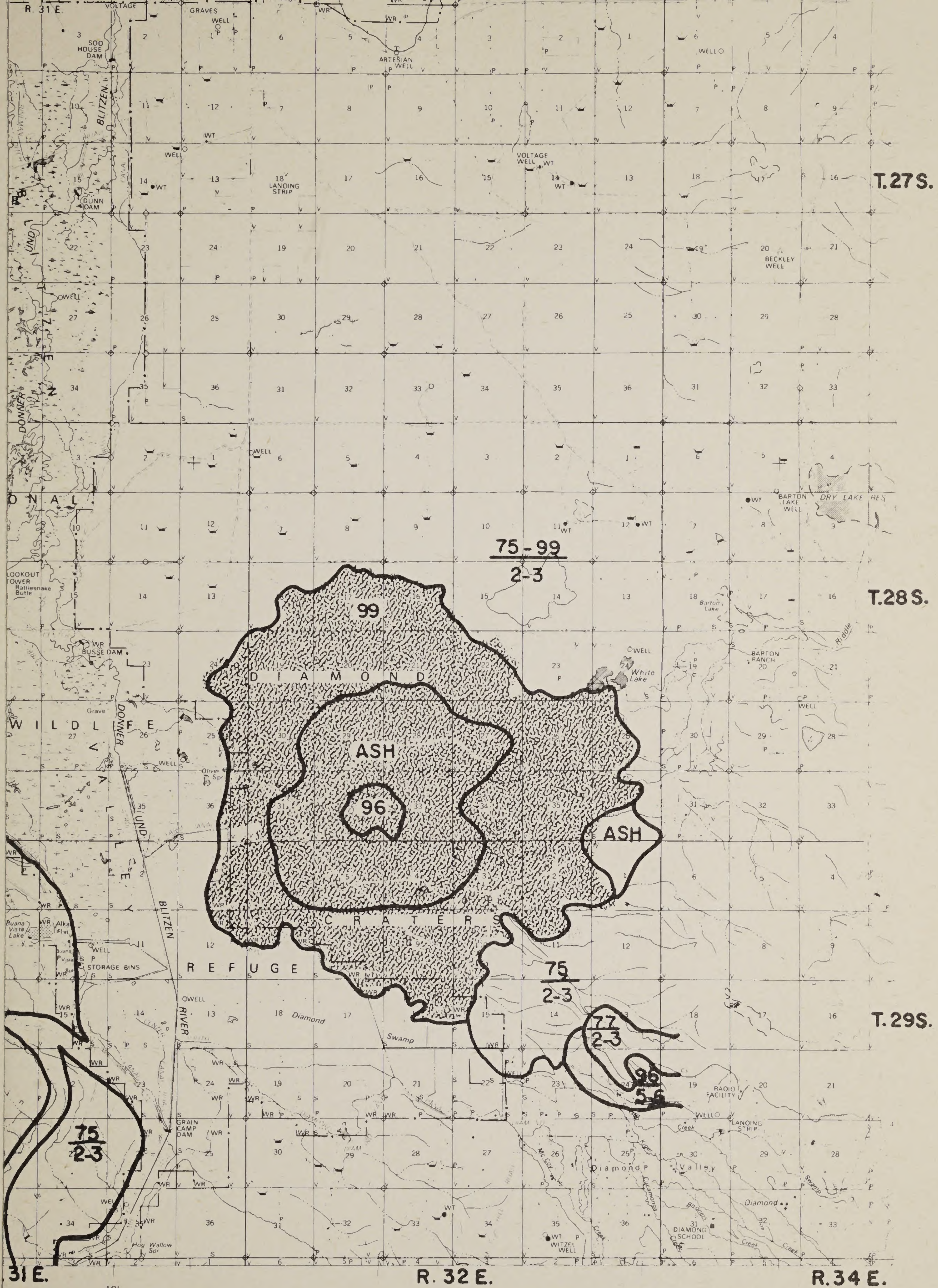


FIGURE 10a
SOILS MAP
(Legend on page 28)


R. 31 E.
T.27S.
T.28S.
T.29S.
R. 32 E.
R.34 E.
31 E.
DIAMOND
CRATERS
ASH
99
96
75-99
2-3
75
2-3
77
2-3
96
5-6
WILDLIFE
VALLEY
REFUGE
BLITZEN RIVER
DONNER UND BLITZEN
VOLTAGE WELL
LANDING STRIP
BECKLEY WELL
BARTON LAKE WELL
DRY LAKE RES
BARTON RANCH
White Lake
BUSSE DAM
STORAGE BINS
GRAIN CAMP DAM
Hog Wallow Spr
Diamond Swamp
RADIO FACILITY
DIAMOND SCHOOL
WITZEL WELL
Diamond Valley
ARTESIAN WELL
GRAVES WELL
SOO HOUSE DAM
DUNN DAM
LOOKOUT TOWER
Rattlesnake Butte
Buena Vista Lake
Oliver Spr

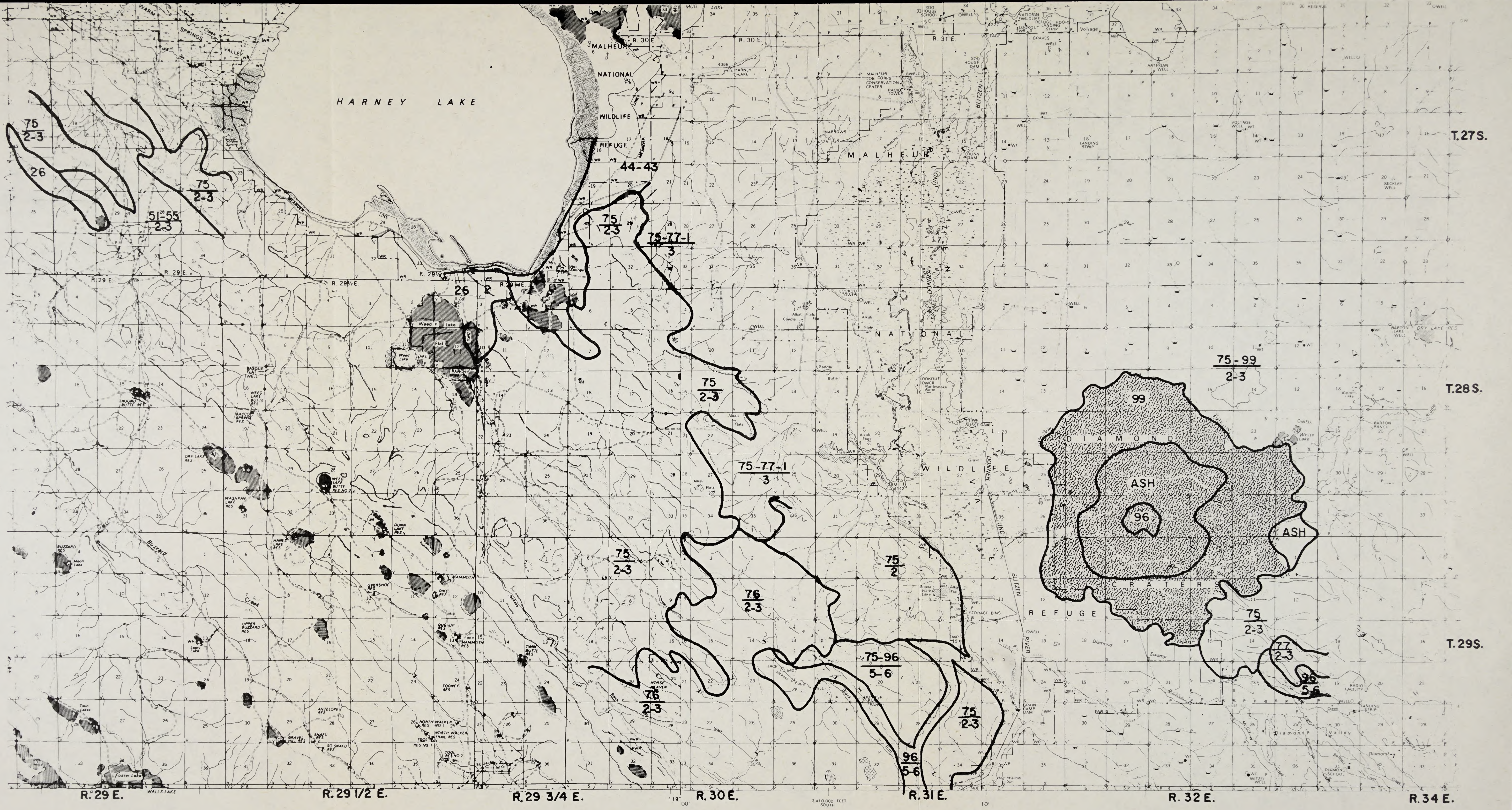


FIGURE 10b
SOILS MAP
(Legend on page 28)

Grass-shrub covered lava plains and plateaus are dominant covering 70 percent (33,438) acres) of the land surface. The mapping units include Units 75, 76, S76, and 77. These units all occur over basalt, rhyolite, or welded tuff. The temperature limitaiton is severe for all.

Unit 75 soils cover 18,958 acres, occurring on rolling lava plateaus from 4,000 to 5,800 feet elevations. The surface and subsurface textures are very stony silt loams with basalt bedrock at 10 to 20 inches. The slopes are mainly 3 to 12 percent, with some areas up to 60 percent. Drainage is good, with runoff slow to rapid on steeper slopes, and permeability moderate. Available water holding capacity is low.

Unit 76 soils cover 6,780 acres, occurring on rolling lava plateaus from 4,500 to 6,500 feet elevation. The surface texture is very stony silty loam, the subsurface stony silty clay with silica and lime coated fractured bedrock at 10 to 20 inches. The slopes range from 3 to 12 percent. Drainage is good with runoff medium and permeability slow. Available water holding capacity is low.

Unit S76 soils cover 2,960 acres, occurring on undulating to steep plateaus from 4,500 to 6,500 feet elevation. The surface texture is extremely stony silt loam, the subsurface extremely stony clay loam to clay with silica and lime coated fractured bedrock at 10 to 20 inches. The slopes range from 3 to 35 percent. Drainage is good, with runoff medium to rapid and permeability slow. Available water holding capacity is low.

Unit 77 soils cover 4,740 acres, occurring on rolling lava plateaus from 4,000 to 6,000 feet elevation. The surface and subsurface textures are very stony gravelly loams with basalt bedrock at 5 to 10 inches. The slopes range from 3 to 12 percent. Drainage is good with runoff medium and permeability moderate. Available water holding capacity is very low.

Sagebrush covered high elevation plateaus and mountains cover 11 percent (5,440 acres) of the land surface. The mapping units include Units 83 and 84. Both these units occur over basalt, rhyolite, or welded tuff. The temperature limitation is severe to very severe.

Unit 83 soils cover 3,400 acres, occurring on rolling lava plateaus from 5,500 to over 6,000 feet elevation. The surface texture is very stony silt loam, the subsurface stony silty clay loam to silty clay with basalt bedrock with calcium carbonate coatings at 10 to 20 inches. The slopes range from 7 to 35 percent. The drainage is good with runoff medium to rapid and permeability moderately slow. Available water holding capacity is low.

Unit 84 soils cover 2,040 acres, occurring on rolling plateaus from 5,000 to over 6,000 feet elevation. The surface texture is very stony gravelly loam, the subsurface stony gravelly loam with welded rhyolitic tuff bedrock at 5 to 10 inches. The slopes range from 7 to 35 percent. The drainage is good with runoff medium to rapid and permeability moderate. Available water holding capacity is very low.

Basins and valleylands, including recent alluvial bottomlands and fans, older fans, terraces and pediments, and lakebeds and lake terraces cover 6 percent (2,764 acres) of the land surface. The mapping units include Units 1, 26, 43, 44, 51, 55, and 56. Temperature limitations are strong to severe.

Unit 1 soils cover 160 acres, occurring on fans and bottomlands on recent alluvial material, from 4,100 to 4,700 feet elevation. The surface texture is silt loam, the subsurface stratified very fine sandy loam and silt loam with bedrock occurring over 60 inches deep. The slope ranges from 0 to 3 percent. Drainage is good with runoff slow and permeability moderate. Available water holding capacity is high.

Unit 26 soils cover 360 acres, occurring on lake terraces underlain by lacustrine sediments, from 4,000 to 5,500 feet elevation. The surface texture is silt loam, the subsurface silt, loam laminated sediments with an effective rooting depth of 15 to 24 inches. The slopes range from 0 to 3 percent. The drainage is good with runoff slow and permeability moderate. Available water holding capacity is low.

Unit 43 soils cover 354 acres, occurring on basin terraces and stream bottomlands, from 4,000 to 4,500 feet elevation. The surface texture is silt loam, the subsurface stratified loam and silt loam with bedrock occurring over 60 inches deep. The slope ranges from 0 to 3 percent. Drainage is somewhat poor with runoff slow and permeability moderately slow. Available water holding capacity is moderate. The soil is strongly alkaline throughout.

Unit 44 soils cover 836 acres, occurring on basin terraces on recent alluvial material, from 4,100 to 4,600 feet elevation. The surface texture is sandy loam, the subsurface silty clay loam to loam, with bedrock occurring over 60 inches deep. The slope ranges from 0 to 3 percent. Drainage is moderately good, with runoff slow and permeability moderately slow. Available water holding capacity is moderate. The soil is strongly alkaline throughout.

Unit 51 soils cover 644 acres, occurring on wind-sorted lake sediments and alluvium, from 4,000 to 4,800 feet elevation. The surface texture is loamy sand, the subsurface loam to sandy loam with bedrock occurring over 60 inches deep. The

slope ranges from 3 to 12 percent. Drainage is somewhat excessive, with runoff slow and permeability moderately rapid. Available water holding capacity is moderate.

Unit 55 soils cover 384 acres, occurring on old fans and high terrace remnants, from 4,000 to 5,500 feet elevation. The surface texture is gravelly loam, the subsurface a silica and lime cemented pan over stratified loamy sand and gravel, the effective rooting depth to the pan 10 to 20 inches. The slope ranges from 3 to 12 percent. Drainage is good with runoff slow to medium and permeability slow. Available water holding capacity is low.

Unit 56 soils cover 36 acres. Their location and properties are the same as those for Unit 55, except Unit 56 soils have a gravelly heavy clay loam subsurface texture over the cemented pan.

Miscellaneous land units comprise the remaining acreage. Unit 96 covers 5 percent (2,088 acres) of the land surface and consists of rough, steep rock land occurring as canyons and escarpments along margins of lava plateaus. Unit 99 covers 7 percent (3,510 acres) of the land surface and consists of recent lava flows on low slopes. Volcanic ash covers 1 percent (440 acres) of the land surface in the Diamond Craters area, and consists of loose cinders.

Soil Erosion

Soil erosion is a function of soil slope, soil texture, organic matter content, infiltration rates, soil cover, and intensity of precipitation. Natural wind and water erosion is low to moderate on most of the undisturbed soils. Natural erosion on the basin and valley lands is low due to the level slopes and medium to fine soil textures. Unit 51 has moderate wind erosion due to its loamy sand texture. On the plateaus and uplands the erosion hazard is low on gentle slopes, and increases as the slope increases.

D. Land Use

The lease offers are in four general areas, with land status as follows:

(1) Diamond Craters

OR 11983	1,887.14 ac.
OR 12418	1,895.68 ac.
	3,782.82 ac.

All the lands in OR 11983 and 1,255.68 acres of OR 12418 are classified for lease or sale under the Recreation and Public Purposes Act of June 14, 1926, as amended. The classification was precipitated by interest of the Oregon State Highway Department (State Parks) in the area in early 1956. The Highway Department made a study of the craters during the summer of 1956. Based on the study, the State Parks Superintendent, in his letter of October 3, 1956, concluded that:

"Since the use is not great at this time and may not be for a number of years, it would appear that the most satisfactory way to administer the area and preserve those features of public interest would be through your administration that new cinder cones be not opened or permits issued that would allow the destruction of the peculiar formations created in the lava flow. In so doing, grazing leases could be continued as you have in the past."

The classification memorandum of November 9, 1956, explained:

"The purpose of such classification is to hold the land in its present status and allow sufficient time for appropriate officials of the Bureau, the State of Oregon, and the National Park Service to examine and consider whether a portion or all of the land can properly be leased or sold to a qualified applicant, or held in withdrawal status and administered by a Federal Agency for recreational purposes."

The classification does not bar mineral leasing.

All the lands in OR 11983 and 1,495.68 acres of OR 12418 are also in a proposed withdrawal as a Research Natural Area. The proposal, under OR 10676, was published in the Federal Register April 26, 1973 (38 F.R. 10282). The withdrawal is proposed to segregate the land from mineral entry for protection of the unique geologic features of the area.

The withdrawal would not prohibit mineral leasing. If and when the withdrawal is finalized, it will displace the R&PP classification noted above, which will be terminated.

OR 12418 is encumbered by a 20 foot powerline right-of-way OR 13629, which serves a stockwater well.

(2) Prather Creek

OR 11750	1,640.00 ac.	
OR 11767	2,315.96 ac.	
	3,955.96 ac.	

Of the lands in OR 11750, 40 acres were acquired in Private Exchange TD 032329 and 80 acres acquired in Private Exchange OR 02786. Both are noted as including "All Minerals" and it is assumed the geothermal resource estate lies with the surface title.

(3) Willow Creek - Burns Butte

OR 12847	1,920.00 ac.	
OR 12849	2,283.48 ac.	
OR 12850	2,200.00 ac.	
OR 12853	1,920.00 ac.	
OR 12856	1,366.19 ac.	
OR 12857	1,833.12 ac.	
	11,522.79 ac.	non-competitive
KGRA	640.00 ac.	competitive
	12,162.79 ac.	total

In OR 12847, 320 acres is patented land, with a reservation of "All Minerals" to the United States. Title to the geothermal resource is undetermined at this time.

OR 12849 is encumbered by U. S. Forest Service 44 L.D. 513 road right-of-way appropriation ORE 12125 and reservoir right-of-way OR 2396, to accomodate a portion of Willow Creek irrigation reservoir. All the land is in oil and gas lease OR 7398.

OR 12850 is encumbered by U. S. Forest Service 44 L.D. 513 road right-of-way appropriations ORE 012125 and ORE 017061. While most of the lands in this application are national resource lands administered by the BLM, 920 acres are National Forest lands, administered by the Snow Mountain Ranger District, Ochoco National Forest. All of the lands are involved in pending oil and gas lease applications OR 7395 and OR 7405.

Of the lands in OR 12856, 80 acres are in pending oil and gas lease application OR 7393. The remainder of the lands are leased for oil and gas under OR 7399.

The KGRA parcel is encumbered by PLO 4858, a reservation for mainline U.S. Forest Service Road, made July 2, 1970 (35 F.R. 11022). The wording of the withdrawal is not available in the District, but it presumably does not bar mineral leasing. The entire parcel is involved in pending oil and gas lease application OR 12551. A mineral material site, containing white pumice, is located in the KGRA. This site was opened about 20 years ago under mining claims since abandoned.

(4) Jackass Mountain - South Harney Lake

OR 11521	2,560.00 ac.
OR 11527	2,120.00 ac.
OR 11530	2,080.00 ac.
OR 11885	2,480.00 ac.
OR 12674	2,562.00 ac.
OR 12675	2,561.02 ac.
OR 12848	2,240.00 ac.
OR 12851	1,936.60 ac.
OR 12852	1,920.00 ac.
OR 12854	1,920.00 ac.
OR 12855	2,551.44 ac.
OR 13865	2,560.00 ac.
OR 13866	1,280.00 ac.
	28,771.06 ac.

In OR 11885, 40 acres have been patented (36660031) with a reservation of "All Minerals" to the United States. Ownership of the geothermal resource is undetermined at this time.

OR 12674 is subject to 40 foot wide powerline right-of-way ORE 012617.

OR 12675 is also subject to right-of-way ORE 012617 and also 100 foot wide highway right-of-way ORE 013541.

The national resource lands are administered under the multiple use management concept, while the private lands are expected to either generate revenue directly or indirectly by supplementing more intensively used properties (ranch base properties).

Domestic livestock grazing is by far the primary economic activity on these lands. They are also managed for wildlife habitat, watershed, recreation and open space.

Diamond Craters is managed for preservation of the unique geological features which are in evidence there, and has no licensed livestock use.

Some of the lands in the Willow Creek area are valuable for rockhound type material, specifically obsidian.

A portion of the lands applied for near Jackass Mountain are adjacent to the Malheur National Wildlife Refuge. The Buena Vista Maintenance Station, a refuge facility consisting of a house, garage, and scenic overlook is located within one-quarter mile of application OR 12675.

Existing land uses are physically compatible in their present intensity, with some minor exceptions. Roads and the mineral material site present some visual resource, livestock grazing and wildlife habitat problems. Other existing and potential conflicts occur between wildlife, livestock grazing, watershed, rockhounding, off-road vehicle use, hunting and other types of recreation.

E. Air

Prevailing winds are westerly with the most wind movement occurring in the spring. Local wind storms with velocities in excess of 60 mph (96 km/hr.) occasionally occur. Warm southwest winds in winter and spring melt accumulated snow and create rapid runoff.

Air quality is good over much of the region. The major sources of particulate matter originates from the Hines mill and transportation vehicles. Occasional dust storms deposit large amounts of particles in the air for short periods of time. Carbon monoxide, hydrocarbon, nitrogen oxide, and sulfur oxide concentrations are all extremely low because of the low traffic volumes, absence of large population centers and small numbers of polluting industries in eastern Oregon.

F. Temperature

Mean annual temperature in the Burns area is approximately 44 degrees F. (7 degrees C). Table 2 is a compilation of the climatological data recorded by the National Weather Service in Burns.

G. Non-Ionizing Radiation

There are no known sources of radiological contamination within the area. The level of non-ionizing radiation on national resource lands and national forest lands is unknown.

H. Water

Table 3 shows the average monthly precipitation as recorded at the National Weather Station in Burns. However, precipitation increases at a rate of one inch for each 100 m (300 feet) gain in elevation. Much of this precipitation falls during the winter months in the form of snowfall. July, August and September are the driest months with less than 10 percent of the annual total precipitation.

Most of the runoff in the lease area occurs in winter and early spring and varies from 2.5 to 5.0 mm (one to two inches). Warm spring chinook winds cause rapid snow melt and consequently heavy runoff.

As typical of eastern Oregon, the evaporation rate is high with pan evaporation varying from 102 mm (40 inches) in the forested areas to 152 mm (60+ inches) in the lower, open valleys.

Average annual sediment production in acre-feet per square mile is less than one-tenth, but varies widely according to

Table 2 *

Average Monthly Temperature

Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
F°	24.8	29.7	37.4	46.0	53.4	56.8	69.5	67.2	58.8	48.4	46.1	29.4
C°	-4.0	-1.3	2.9	7.7	11.7	13.6	20.6	19.3	14.7	9.0	7.8	1.4

Table 3 *

Average Monthly Precipitation

Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
in.	1.76	1.18	.92	.70	1.03	.97	.32	.44	.46	.89	2.42	1.73
cm.	4.47	3.00	2.39	1.78	2.62	2.46	.81	1.12	1.17	2.26	6.15	4.39

* Source: Climatological Data, U. S. Department of Commerce

geology, soils, amount of runoff, slope, land treatment practices and upstream watershed conditions. Many of the smaller streams have little or no flow except during periods of melting snow and high runoff. Water temperatures for many of these streams are commonly 21 degrees C (70 degrees F) or higher in late summer and near freezing from November to April. They are generally well aerated with dissolved oxygen concentrations near saturation levels, averaging 8 to 12 mg/liter.

Water quality of the perennial streams is good to excellent but decreases substantially in the downstream portions because of increases in mineral content. The amounts of calcium and sodium vary; calcium is usually predominant during high flow periods.

Coliform contamination is generally low in surface waters due to the low human population density. The coliform counts are higher in the areas of animal concentrations and soil bacteria.

Ground water is usually found in alluvial deposits and some volcanic rocks at a depth of 18 to 180 m (60 to 600 feet). These volcanic rock aquifers are only moderately permeable but the annual recharge to these aquifers is very low. The quality of the ground water is fair to good. The main water source for the city of Hines is located in alluvial material adjacent to the lease area.

Several reservoirs are located in the geothermal lease areas, most of which are less than 3 acre-feet. The primary purpose of the reservoirs is to provide water for livestock, but also provide water for wildlife and habitat to the aquatic plants and amphibians. The availability of water in these reservoirs is adequate in most years. Projected needs for municipal, industrial, domestic, and livestock water will double by the year 2020. Ground water supplies are estimated to be adequate to meet the demand.

All of the streams flow into the Harney Basin which has no outflow. The Harney Basin watershed provides the all important habitat for waterfowl. However, the Malheur Lake levels fluctuate greatly from year to year. In 1972, a high water year, 250 cubic hectometers (200,000 acre-feet) flowed into the lake. In 1973, only 90 cubic hectometers (75,000 acre-feet) flowed into Malheur Lake. During the high water year of 1972, the Donner und Blitzen River contributed 55 percent of the inflow, with the Silvies River, direct precipitation, and Sodhouse Spring contributed 28, 13, and 4 percent respectively.

In the drought year of 1973, the Donner und Blitzen River was again the principal contributor of water with 62 percent of the total inflow. The Silvies River, direct precipitation, and Sodhouse Spring contributed 1, 25, and 12 percent respectively.

Groundwater inflow, other than Sodhouse Spring, appears to be negligible. A large amount of the snowmelt runoff does not reach the Malheur Lake because the stream waters are diverted for irrigation use.

Most of the outflow from the lake is from evapotranspiration (81 percent in 1972 and 96 percent in 1973), but some surface outflow from Malheur Lake goes through the Narrows into Harney Lake. Groundwater outflow also seems negligible.

A discussion of water resources provided by the U. S. Geological Survey can be found in Appendix A.

Selected References

U. S. Geological Survey, 1975, Hydrology of Malheur Lake, Harney Co., southeast Oregon: U. S. Geological Survey Water Resources Investigations 21-75.

Phillips, K. N., 1969, Water Resources of Oregon: Mineral and Water Resources of Oregon, Oregon Department of Geology and Mineral Industries, Bill 64.

Western U. S. Water Plan Study for Oregon, 1973, U. S. Department of Interior, Bureau of Reclamation and Pacific Northwest River Basins Commission, Salem, Oregon.

I. Vegetation

Willow Creek-Burns Butte - The major vegetation types are low sagebrush (Artemisia arbuscula), big sagebrush (Artemisia tridentata) and Western juniper (Juniperus occidentalis). Each species is present in differing percentages as overstory vegetation within a community type. However, when lumped together these communities cover 83% of the total area. The dominant grass species is Sandberg's bluegrass (Pos sandbergii), which represents 71% and is associated with all overstory communities. Bluebunch wheatgrass (Agropyron spicatum) represents 29% of the area and is generally associated with big and low sagebrush.

Diamond Craters - Although no study has been completed as to the plant communities in the area the plants list in table 4 are known to occur there.

Jackass Mountain - Big sagebrush covers approximately 92% of the area. The big sagebrush type is associated with three understory grass species (Japanese brome, Bromus japonica, 12%; bottlebrush squirreltail, Sitanion hystrix, 77%; and Sandberg's bluegrass, 3%). Six percent of the remaining area is low sagebrush associated with Sandberg's bluegrass, while the other 1% is associated with bottlebrush squirreltail. Only 1% of the area is covered with spiny hopsage (Grayia spinosa).

Prather Creek - The major community type is low sagebrush covering 75% of the area with varying amounts of Sandberg's bluegrass and Japanese brome together totaling approximately 95%. Approximately 11% is composed of Western juniper with the associated overstory species being big sagebrush. Other grass species present include needlegrass (Stipa) and bottlebrush squirreltail.

South Harney Lake - The major overstory community type is big sagebrush composing 71% of the area. Other overstory vegetative types include black greasewood (Sarcobatus vermiculatus) and spiny hopsage (Grayia spinosa) covering 28 and 1 percent, respectively. The major grass species is bottlebrush squirreltail covering approximately 87% of the area, while other grass species including desert saltgrass (Distichlis stricta) and Sandberg's bluegrass covered 10% and 3%, respectively.

At the present time no rare or endangered plants are known to occur on any of the leasing sites. An inventory is planned for the 1977 field season which will cover the Willow Creek-Burns Butte, Jackass Mountain, and South Harney Lake leasing areas.

Selected References

Pacific Northwest Forest and Range Experiment Station, 1976. Northwest Plant Names and Symbols for Ecosystem Inventory and Analysis. 4th ed. Dept. of Agr. Portland, Oregon.

Hitchcock, C. L., and A. Cronquist. 1973. Flora of the Pacific Northwest.

Bureau of Land Management. 1960-1964. Range Survey of East Silver Creek, Camp Harney, and Warm Springs Units.

Table 4

This table shows plant genera or species that are thought or known to occur in the areas of Willow Creek-Burns Butte, Jackass Mountain, Prather Creek and South Harney Lake. The list does not include those species that were discussed in the narrative.

Achillea millifolium	Agoseris
Agropyron	Anteneria
Astragalus	Blepheripappus scaber
Circium	Creepus
Epilobium	Erigeron
Erigogonum	Leppidium
Mimulus	Navarretia
Oenothera	Orobanche
Penstemon	Phacelia
Potentilla	Scutellaria
Trygapogon	Urtica

Teh following plants are known to occur in the Diamond Craters area by Dr. Karl Holte of Idaho State University.

Achillea millefolium	Juniperus occidentalis
Nama densum	Phacelia leucophylla
Marrubium vulgare	Scutellaria antirrhinoides
Mentzelia laevicaulis	Oenothera tanacetifolis
Eriastrum strictum	Ribes cereum
Holodiscus dymosus	Prunus virginiana
Mimulus cusiekii	Penstemon deustus
Nicotiana attenuata	Senecio canus
Stipa spp.	Artemisia tridentata
Chrysanthamus	Oryzopsis hymenoides

J. Wildlife

A list of wildlife species that may be present in the proposed lease area is found in Appendix D.

The proposed lease areas contain many diverse habitat types, but may be divided into two "life zones" to distinguish large differences in bird species presence and abundance. These two zones are the Confier and the High Desert. Only the most northerly part of the proposed lease area is in the Conifer Zone; parts of tracts in T.22S., R.29E. Bird species such as brown creepers, Swainson's thrush, and ruffed grouse are strongly dependent on confiers while others, such as, Brewer's sparrow, western meadowlark, and sage thrashers are usually found in the lands south of the conifers.

The transition area between these two life zones may find considerable mixing of animal species. All of the areas have little water available to wildlife.

A brief discussion of wildlife by areas follows:

<u>South Harney Lake - Jackass Mountain</u> - Mule deer winter in the southern part of this area. A few deer summer in the juniper covered rims south of Jackass Mountain.

Antelope may be found throughout the area, but are usually observed near Weed Lake Flat and near Jackass Mountain.

Sage grouse are found throughout the area. Sage grouse nests have been located near the tracts in T.27S., R.29E., Sec. 17, 19, 20 and 21, and probably nest in those tracts. Sage grouse strutting grounds have been documented in T.29S., R.30E., Sec. 14 and 23, and others probably exist.

Chukars may be found in the rocky rims west of Highway 205. Sparse populations are also occasionally observed in rocky rims in the Jackass Mountain area.

Burrowing owls are occasionally found in the area.

Valley quail are sparsely distributed. Populations have been observed along the main access road south of Harney Lake and along Highway 205. We have one documentation of mountain quail near the lease area, in either Sec. 4 or 9, T.30S., R.31E., but this is a rare occurrence.

Dabbling ducks, Canada geese, shorebirds, and other aquatic birds use the hot springs fed pond in T.27S., R.30E., Sec. 36 (deeded land). The ephemeral lake in T.8S., R.29-3/4E., N½ Sec. 1 (Malhuer Refuge) contained an estimated 50 s.a. of water the fall of 1976, but received little use by birds.

Golden eagles nest in the area, particularly along the rim south of Harney Lake and the rim west of Highway 205 (Figures 11a and 11b). The two nests in T.29S., R.31E., Sec. 22, often are active. The three nests south of Harney Lake were active in 1976 (Littlefield 1976 *).

Northern bald eagles are winter residents, usually in low numbers. Northern bald eagles are on the Oregon Endangered Species list. **

Diamond Craters - The abundance of rocky rims in this area strongly influences animal species presence. Wildlife common to rim areas, such as bushy-tailed woodrats, western rattlesnakes, and canyon wrens, are relatively abundant in Diamond Craters. This area provides a wider diversity of wildlife species than adjacent relatively flat rangeland.

The dark soil and rock color in the area also appears to influence wildlife. Great horned owls, Great Basin fence lizards, and other species found in the area are Melanistic. Diamond Craters provides a good area for the study of adaptive coloration (Ferguson 1976***).

Diamond Craters contains a population of western whiptail lizards. This is the most northerly population of this species documented in Harney County, but they do occur farther north, along the Snake River in Baker County (Ferguson 1976***).

Golden eagle nests have been documented to the west of Diamond Craters, on the Malheur Refuge, and within the craters. The two nests on the refuge (Figure 11b) have not been active the last two years while the nest in T.28S., R.32E., Sec. 32, was active in 1974, 1975, and 1976 (Littlefield 1976*)

Great horned owls and turkey vultures also nest here. Sage grouse are occasionally observed in the area.

Antelope are rarely observed in the tracts proposed for leasing, but are commonly found north of here.

Occasionally mule deer are found in Diamond Craters, usually in the winter.

* Personal communication Guy Sheeter, Burns District BLM, and C. D. Littlefield, U.S. Fish & Wildlife Service, Burns, Ore., Oct. 19, 1976.

** Endangered plants and animals of Oregon III Birds. Special Report 278. July 1969, OSU.

*** Personal communication, Guy Sheeter, Burns District BLM, and Denzel Ferguson, Malheur Environmental Field Station, Oct. 12, 1976.

Dabbling ducks and other aquatic birds use Diamond Craters Pond and adjacent aquatic habitat on the Malheur National Wildlife Refuge. Most of the use is during the spring and fall migrations. In addition, waterfowl, shorebirds and other aquatic birds fly over Diamond Craters to Diamond Valley, Dry Lake, and other aquatic habitat east of the Malheur National Wildlife Refuge. Largemouth bass are found in Diamond Craters Pond.

Prather Creek - Devine Ridge - The lower part of this area, south of Line A (Figure 11a), contains a sparse stand of juniper that provides valuable cover to wintering deer and a few summering deer. The area north of line A (Figure 11a) has a much denser juniper cover than south of it, receives more use by both summering and wintering deer, and receives more use than the southern area. During the winter, deer move off the Malheur National Forest to their winter range, including the Prather Creek area. Forage is probably the limiting factor for deer wintering in this area. Bitterbrush is severely hedged and/or dead. Competition for forage between cattle and deer is keen here.

Occasionally antelope use the Prather Creek area. Winter elk use occurs, but is rare.

Sage grouse and mourning dove are found here. No sage grouse strutting grounds have been documented, but may occur.

Willow Creek - Radar Base Hill - This area is deer summer range. During open winters it receives considerable use by wintering deer. It contains a good interspersion of cover, although parts of it have open valleys over one mile wide. Important deer cover and forage species include curl-leaf mahogany, bitterbrush, and big sagebrush. In addition, juniper provides valuable cover. Ponderosa pine forms much of the cover, along with juniper, in parts of T.22S., R.29E., Secs. 28, 21, 20, 16.

Water is sparsely distributed in most of this area and by late summer some reservoirs are dry.

Antelope utilize the area, primarily as a summer range. Most of the use is in the more open low sagebrush covered valleys, particularly Willow Flat, adjacent to parts of the proposed lease area.

Sage grouse are found throughout the lower cover types. Three sage grouse strutting grounds have been documented on the edge of the proposed lease, but others may exist. Mourning dove nest here, particularly in the juniper type.

A small chukar population is occasionally observed in T.23S., R.30E., Sec. 20. Valley quail are infrequently observed.

Bald and golden eagles have been observed here. Bald eagles are winter-spring residents while golden eagles may be found yearlong in low numbers. Red-tailed hawks commonly nest in the ponderosa pine type.

K. Ecological Interrelationships

Because of the variety of sites and corresponding plant communities, plant successions are complex and diversified. The following is a broad overview of the more prominent successional patterns.

Juniper woodlands are dependent upon different factors. The older juniper trees are generally found in small swales and on rocky ridges with relatively deep soil between the rocks. Heavy grazing over a prolonged period and suppression of natural fires have greatly extended the area covered by this species. Juniper is adapted to a wide range of sites and with adequate moisture it may invade rapidly as perennial grasses and shrubs lose vigor. Once established, juniper generally maintains dominance of a site. Perennial grasses and shrubs are forced out and tree interspaces support annual forbs and grasses. The degree of plant variety decreases with the severity of the site.

The sagebrush communities can be broken into two general categories--big sagebrush and low sagebrush. Low sage generally occurs on the shallow stony sites of well drained upland plateaus.

Big sagebrush is best adapted to deep, well drained soils and is often found in association with bitterbrush and rabbitbrush. Due to the combination many of the preferred browse and grass species have declined and the extent and density of sagebrush and rabbitbrush have increased.

On many deer winter ranges, sagebrush is a critical browse. This grazing use, domestic livestock grazing, plus other land disturbances, has resulted in an increase in grey rabbitbrush and cheatgrass.

There are other factors besides grazing that have initiated ecological changes. Road building, hunting and recreation use have caused deteriorated conditions in varying degrees.

These deteriorated conditions allow increased runoff and a consequent increase in soil movement. Poor watershed conditions cause increased sediment loads from sheet, rill, gully and channel erosion. Erosion reduces the plant production potential by reducing soil fertility, thus reducing the availability of suitable habitat for forage species.

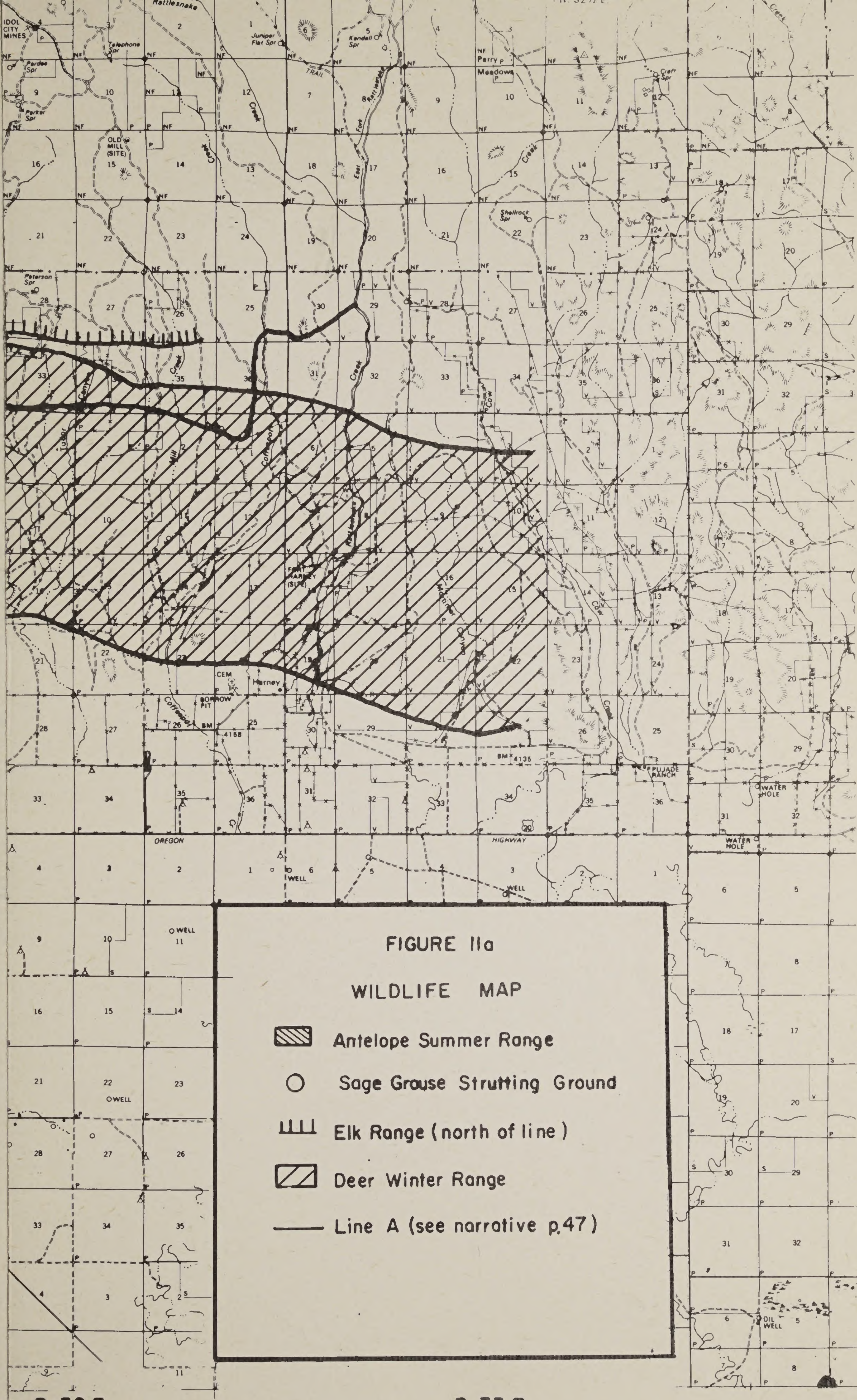


FIGURE IIa
WILDLIFE MAP
Antelope Summer Range
Sage Grouse Strutting Ground
Elk Range (north of line)
Deer Winter Range
Line A (see narrative p.47)
T. 21 S.
T. 22 S.
T. 23 S.
T. 24 S.
R. 32 E.
R. 33 E.
OREGON
HIGHWAY
Harney
PUJADE RANCH
FORT HARNEY (SITE)
OLD MILL (SITE)
IDOL CITY MINES

A small chukar population is occasionally observed in T.23S., R.30E., Sec. 20. Valley quail are infrequently observed.

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FIGURE 11a
WILDLIFE MAP
Antelope Summer Range
Sage Grouse Strutting Ground
Elk Range (north of line)
Deer Winter Range
Line A (see narrative p.47)
T. 21 S.
T. 22 S.
T. 23 S.
T. 24 S.
R. 28 E.
R. 29 E.
R. 30 E.
R. 31 E.
R. 32 E.
R. 33 E.
BURNS
INDIAN
RESERVATION
Burns
Hines

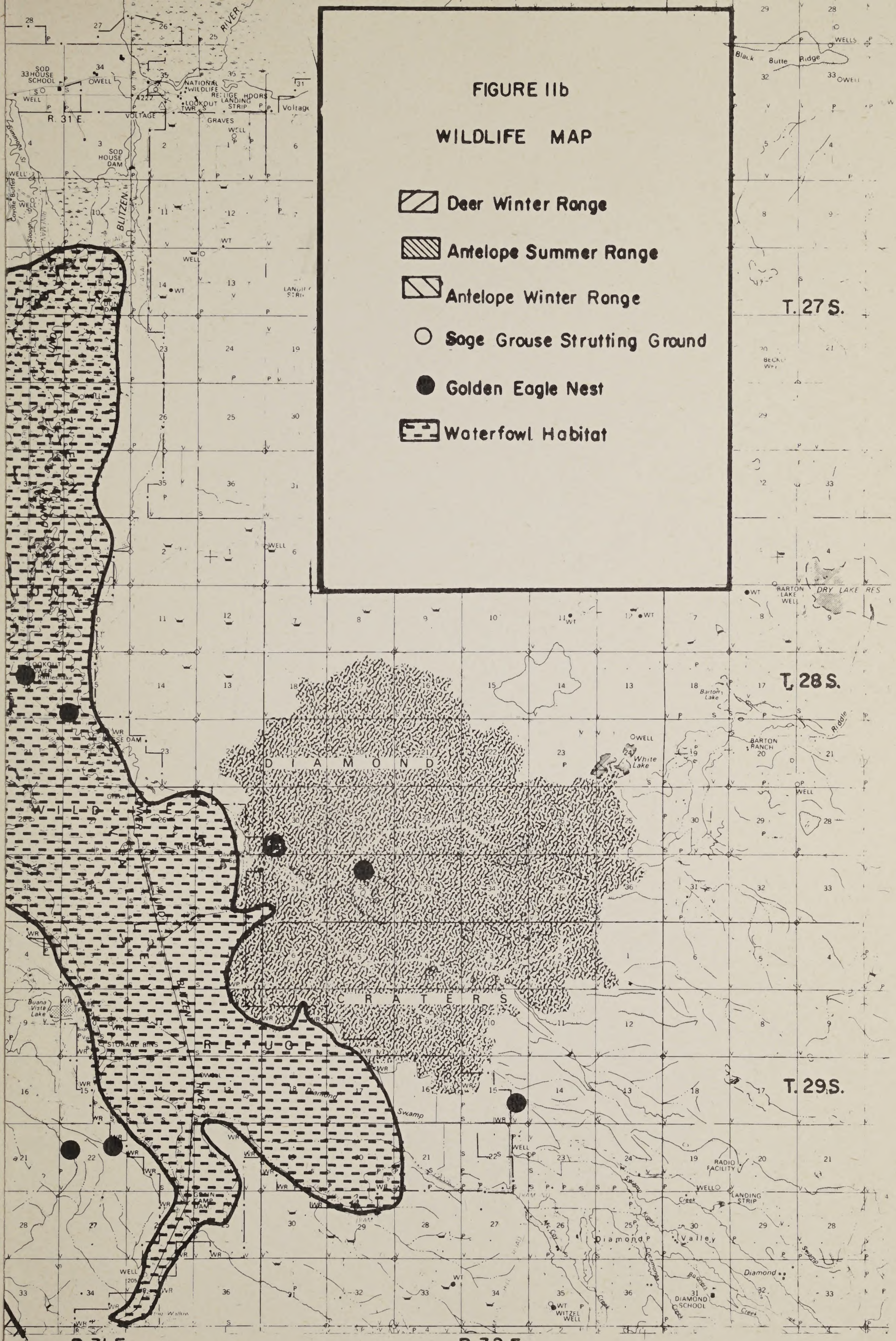
FIGURE IIb
WILDLIFE MAP
Deer Winter Range
Antelope Summer Range
Antelope Winter Range
Sage Grouse Strutting Ground
Golden Eagle Nest
Waterfowl Habitat
T. 27 S.
T. 28 S.
T. 29 S.
R. 31 E.
R. 32 E.
DIAMOND
CRATERS
REFUGE
DRY LAKE RES
White Lake
Barton Lake
BARTON RANCH
DIAMOND SCHOOL
WITZEL WELL
Diamond Swamp
Diamond Valley
RADIO FACILITY
LANDING STRIP
BLITZEN

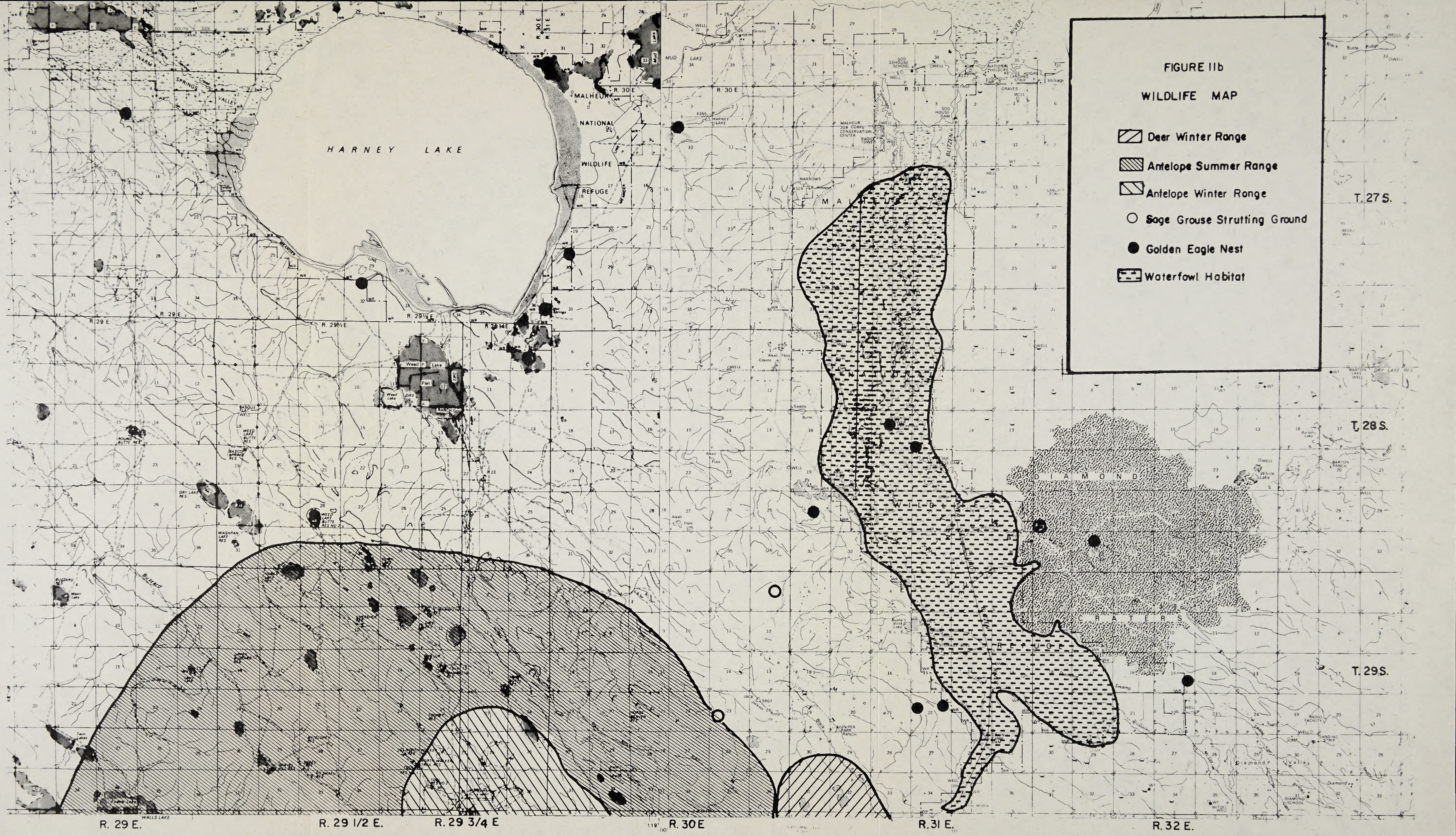

FIGURE IIb
WILDLIFE MAP
Deer Winter Range
Antelope Summer Range
Antelope Winter Range
Sage Grouse Strutting Ground
Golden Eagle Nest
Waterfowl Habitat
HARNEY LAKE
MALHEUR NATIONAL WILDLIFE REFUGE
DIAMOND CRATERS
T. 27 S.
T. 28 S.
T. 29 S.
R. 29 E.
R. 29 1/2 E.
R. 29 3/4 E
R. 30 E.
R. 31 E.
R. 32 E.

The natural ecological trend is slow movement towards a mature stand of dominant species. Many successions initiated by past improper land uses are reversible. The reversal of the pattern, especially if time is important, may require drastic action such as chemical and/or mechanical vegetation conversion for wildlife, watershed and livestock values.

Food and Community Relationships

Within the lease area there are numerous food relationships between plants and animals. All are dependent initially upon the production of food materials by green plants. The existing vegetation and many other environmental factors dictate what animal species will inhabit an area.

Deer are dependent upon specific seasonal use areas to provide year long forage, water and cover. Forage requirements and availability change with the season.

Domestic livestock, on the other hand, do not require the same variety of forage. They can survive some seasons on strictly a grass diet.

Predators such as coyotes, bobcats, badgers and raptors prey primarily on rodents, rabbits, other small mammals and reptiles. Rodent and rabbit populations are somewhat cyclic and governed to a large extent by production of forage and seeds for food. During periods of low rodent and rabbit populations predators may shift to prey species that are available or may change feeding ranges until food sources improve.

The most critical component of all the food relationships is water. The seasonal and geographic distribution of water supplies strongly influence the numbers and distribution of floral and faunal species. Water developments such as spring improvement and reservoir construction often enhance and expand habitat for many species. Natural water supplies may require supplementation, particularly in drought years, in order to sustain dependent populations. The water supply is often the limiting factor in the food chain.

L. Human Values

Although it does not contain as much variety as other parts of Oregon, the lease area does possess different topographic features and vegetative types. The Harney Lake area is a harsh desert area of sagebrush, greasewood and alkali soils. The Willow Creek, Prather Creek, and Jackass Mountain areas are essentially sagebrush and juniper-covered uplands. The Diamond Craters area still has the appearances of a recent volcanic eruption with its craters, spatter cones, and platy lava flows. Although roads, stockwater ponds, and fences in these areas make one aware of man's activities, there still remain elements of open spaces.

Educational and Scientific Values

The Diamond Craters area with well preserved volcanic features such as driblet spires, uncollapsed lava tubes, pahoehoe lava, and spatter cones make it interesting geologic study area. The area also contains small reptiles, rodents that provide an interesting biological study area. The Malheur Environmental Field Station conducts educational tours of the Diamond Craters area.

Historical Values

The first white men to enter Harney County were fur trappers and traders. They were in the area as early as 1824. The Silvies River is named after Antoine Sylvaille, who trapped the country in 1824-25. Their expedition ended in misfortune, their furs and horses being stolen by the Indians, and it is presumably from this event that the Malheur River derived its name. In free translation the name means "bad hour".

Emigrants, miners, and the military later traveled through the area. The infamous Meeks wagon train cut-off in 1845 proclaimed as the fastest route to the Willamette Valley, labeled the country as an endless wasteland. Miners crossing the Harney Basin to the gold fields in Auburn, Canyon City and Idaho in the early sixties spread knowledge of lush valleys. The military, to protect the miners and west bound emigrants, established several posts in the mid-sixties. The first roads were begun at this time, made possible by Federal land grants.

Credit for the permanent settlement of Harney County must go to the early cattlemen. Seeking big country and open range (California had passed a trespass law in 1864) they moved their herds in from California, Nevada, and western Oregon. John S. Devine was the first to settle in 1869. They built huge cattle empires, much of the land being claimed by fraud under the Swamp Act of 1860.

In 1872 the federal government created the "Great Paiute Reservation" of 2,285 square miles. After the Bannock-Paiute uprising of 1878, in retribution the Indians were dispensed to other reservations, and the Paiute reservation lands were thrown open to settlement. By 1880 the military had left the country and a large number of homesteaders were present.

The town of Burns wasn't founded until 1884 when George McGowan named the town after the Scottish poet Robert Burns and a post office was opened. The small community progressed slowly until the coming of the railroad in 1924 and the construction of the mill in Hines in 1930. Subsequently Burns became the dominant center of commerce in the county. Today, Harney County has a population of about 7,200, 4,700 of which reside in the towns of Burns and Hines.

There are no known historic structures within the lease areas. The Oregon State Inventory of Historic Sites lists two sites bordering the lease areas; Harney Lake Sand Gap (Section 18, T.27S., R.30E.) and the Malheur National Wildlife Refuge. The historic Malheur Indian Reservation of 1872 encompassed two of the lease areas (Prather Creek and Willow Creek), but it left no enduring features in these areas. The famous Meeks Cut-off may have crossed part of the lease area, but the precise route is not known.

Selected References

Harney County, Oregon and its Range Land, Brimlow, 1951, Binfords.

Historical Notes, Harney County Historical Society.

Oregon Geographic Names, L. A. McArthur, 1974, Oregon Historical Society.

Archaeological Values

The Northern Paiutes - The Indians occupying southeastern Oregon in 1850, historically referred to as Snake, Bannock and Diggers, were really Northern Paiutes. They were not organized as a tribe, but rather as a series of independent bands all speaking similar dialects of one linguistic family. Political organization within these bands was not strongly developed and leadership was based on individual qualifications. Each band followed a seasonal migratory pattern within a distinct territory. The band occupying the Harney Basin was called Wadatoka (wada seed eaters).

For the fifty years prior to their final confinement to reservations in the 1870's, the lifeways of the Paiutes underwent radical change and adaptation to encroachment by whites. The undisturbed precontact way of life was never recorded. Ethnographic studies have rescued information on the historic Paiutes, but it is the task of archaeology to reconstruct aborginal lifeways prior to contact and the acquisition of the horse.

The prehistory of the Northern Great Basin (roughly southeastern Oregon) as it stands today has four developmental stages. Three of these represent different cultural traditions or types of culture. The fourth phase is a period of transition (Bedwell, 1973).

The earliest record of man's presence in the Great Basin comes from a period referred to as the Western Clovis Tradition or the Fluted Point Tradition. Roughly, this tradition lasted from 14,000 to 11,000 years ago. The climate was relatively cool and moist. Large Plestocene lakes existed in the Catlow,

Alvord, and Harney Valleys. Numerous small lakes were scattered throughout the area. Fossil lake terraces in Catlow Valley have been recorded at as much as two hundred feet above the present floor (Cressman, Williams and Krieger, 1940).

The Western Clovis Tradition is characterized by stemless, unnotched projectile points and a large, broad blade technology. Milling stones are not common but present in the unit. The assemblage suggests a generalized hunter-gatherer adaptation and maybe some big game hunting. Evidence for a Big Game Hunting Tradition in the Great Basin is still in question. Based primarily on typological analogy to the Plains-based Paleo-Indian hunters, there stands, at the moment, nothing against the possibility that fluted points found in the western and northern Great Basin were used to kill anything but small to medium sized game (Heizer and Baumhoff, 1970). The faunal data from Fort Rock, Conley, and Cougar Mountain Caves in southeastern Oregon suggests a balance in the ratio of large to small game. This fact supports the view that the Western Clovis Tradition was not highly specialized but rather pursued a wide exploitation of the environment.

Following the Western Clovis Tradition is the <u>Western Pluvial Lakes Tradition</u>, lasting from 11,000 to 8,000 years ago. By the middle of the Anathermal (11,000 years ago) the Pleistocene lakes of the Great Basin ceased to exist as single bodies. Lowering of precipitation had reduced them to shallow, open-water lakes, attractive to waterfowl, shore birds, and a variety of large and small game animals as well as to man. The lakes of Harney and Malheur counties lacked the important fish runs from the sea. While archaeological evidence indicates a great reliance on lacustrine resources, it may be that the possibility of few or no fish in the lakes inhibited the development of a fishing technology. Early levels at Catlow Cave show a predominance of waterfowl in the faunal remains, but no skin-covered, reed duck decoys, few fishbones, and no fishnets or fishhooks have been recovered from the Oregon caves (Rozzire, 1963).

With the progressive warming and drying trend and virtual evaporation of the lakes the Indians gradually expanded their exploitative pattern. While previously it had been feasible to remain relatively sedentary around the lakes, increasingly the environment demanded over widening migrations into the hinterlands. The beginning of this transitional period is apparent in the archaeological record about 8,000 years ago and correlates with the onset of the arid Altithermal climatic phase.

From 8,000 to 7,000 years ago occupation intensity declined suggesting a period of instability. By 7,000 B.P. truely arid conditions prevailed and were to persist for two thousand

years. The lake and marsh environments had disappeared. Earlier researchers hypothesized nearly total abandonment of the area at this time by the inhabitants. Bedwell suggested that while abandonment may have occurred in part, it is possible that some springs survived, probably at the higher elevations, and that these may have attracted the inhabitants. A study completed in 1974 confirmed Bedwell's hypothesis of Altithermal occupation of spring sites (Fagan, 1974).

Sometime after 5,500 B.P. the climate began to improve attaining conditions similar to the present. By this time the Desert Culture Tradition had evolved and lasted virtually unchanged for the next two thousand years. Typical of this period are small, corner-notched projectile points, continued refinement of the pressure flaking technique, basketry, cordage, and matting. Food-grinding implements (manos, metates, and mortars) appear in far greater numbers than previously. This indicates an increased skill in seed and root food preparation and may suggest a greater dependence on vegetable foods in the diet.

The Desert Culture in the Great Basin did not represent a single eoconomic pattern, but rather involved an exploitation of both desert, lacustrine and mountain resources. In some areas regional specialization resulted from distinctive local ecological conditions. In the Northern Great Basin the Warner Lakes area provided a suitable environment for a lacustrine adaptation. By 3,500 years ago a regional variant of Desert Culture was established in this area (Weide, 1968).

Calculations for the introduction of the bow and arrow into the Great Basin vary somewhat. Aikens (1970) thinks it had occurred about 3,000 years ago. Hester (1973) suggests that it was introduced about A.D. 500. With its introduction the longer dart point forms subsided or disappeared altogether. They were replaced by small, triangular arrowpoints (Rose Spring and Eastgate points). Hester feels there is no substantial evidence that use of the bow and arrow brought about any change in economic pursuits.

Around A.D. 1000 much of the Great Basin saw the introduction of brownware ceramics and Desert Side-Notched and Cottonwood projectile points. It is believed that these materials mark the advent of Numic speakers (Paiute and Shoshonean) in the Great Basin.

Archaeological Potential of the Lease Areas - None of the proposed lease tracts have been professionally surveyed. The State Historic Preservation Office was consulted. A search of their files and those of the University of Oregon did not reveal any sites located within the lease areas.

The archaeological potential of the Prather Creek tract is unknown. The Willow Creek-Burns Butte tract contains an exceptionally large obsidian quarry and a large number of smaller sites and chipping stations adjacent to it. Most of the quarry is contained in Section 20, T.23S., R.30E. Dr. Thomas Newman of Portland State University has informed the Bureau that obsidian quarries of this size are extremely rare.

The Diamond Craters lease area has not been surveyed. The crater area itself does not have great potential for archaeological values, but the reverse is true along its borders.

The Harney Lake lease area has not been systematically surveyed. Harney Lake was formerly a large Pleistocene lake, and during the time of man's known occupation of the area, should have provided a relatively fertile environment for human habitation. Many sites have been recorded on Refuge land along the lake's border. Some of these sites are contiguous with the lease tracts. One site has been located by the district archaeologist within the lease area (Section 11, T.28S., R.29-3/4E.). All sections near Harney and Weed Lakes have high potential for archaeological values.

Many sites have been recorded on Refuge lands to the east of the Jackass Butte portion of the lease area. Sections bordering the Blitzen Valley have great potential for archaeological values.

To the interior of the Harney Lake-Jackass Butte lease area archaeological site densities are likely to decrease. It is suspected that sites may occur along good drainages. The district archaeologist has done some survey work in the area. No sites have been noted. The potential is low for the area.

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Recreation

One important recreation area lies in the proposed lease area. Diamond Craters is an area of educational and scientific value which lends to its importance of geological, botanical, and zoological sightseeing. For this reason it has been proposed as a Natural Research Area. A Natural Research Area is established and maintained for the primary purpose of research and education. Scientists and educators are encouraged to use research natural areas in a manner that is nondestructive and consistent with the purpose for which the area is established. However, the general public may be excluded or restricted where necessary to protect studies or preserve research natural areas. This may destroy the recreational opportunities and sightseeing in the area. Lands having the following characteristics may quality:

(1) Typical or unusual faunistic or floristic types, associations, or other biotic phenomena, or

(2) Characteristic or outstanding geologic, pedologic, or aquatic features or processes. Also under this category, no person shall use, occupy, construct or maintain improvements in natural research areas in a manner inconsistent with the purpose for which the area is established. If the proposed area is approved, then geothermal development would be inconsistent with the management of a natural research area.

The Burns district recreaton specialist recommends that a complete interpretative plan for the Craters should be undertaken to aid and inform visitors of its geologic botanical and zoological interest. Vehicles would be restricted to a few main roads. Four wheel drive and secondary roads would be blocked to protect the area. Hiking trails outside fragile geologic sites would be established to channel and direct use. The High Desert Hiking Trail is proposed to cross the Craters area along the county road. This would cause no problems with protecting the area.

The most stiking visual characteristic of this area is the geologically recent volcanic area. The exposed lava flows, vents, and craters interspersed with pockets of vegetation are the dominant feature in the Craters area.

The Malheur Maar is a unique waterbody which has formed in a volcanic crater. It has approximatley one acre of surface water surrounded by a narrow band of marsh vegetation and is contained by nearly vertical crater walls.

The Diamond Craters area was evaluated for its recreational value which includes such items as zoological and geological sightseeing values. Overall, the area was rated as an interesting portion of Harney County, but would be considered as common scenery to the causual visitor. It was also rated for its visual resource management opportunities. The conclusion was that the Diamond Craters fell into a Class II management category. This class requires management activities such as constructing a visitor information center or constructing a geothermal power plant to be designed and located to blend into the natural landscape and not to be visually apparent to the casual visitor.

Social Welfare

More than half of Harney County's population is centered in the Burns-Hines area and the rest is sparsely scattered throughout the county. The rural population is based primarily on ranching. Harney county has the smallest population density in the state and has had little migration over the years, so that the slow growth can be attributed to natural increases. The major industries are lumber, livestock, agriculture and tourism. Wood products and lumbering are by far the largest industries in the area with wood products contributing 55 percent of the total payroll for the county. Most of the timber comes from the Ochoco and Malheur National Forests.

Livestock inventories have not increased, partly because of the recent troubled beef markets, but does show strong secondary employment characteristics. Moreover, the Bureau of Land Management has a profound impact on livestock production in the county.

The recreation industry brings little income into the county because the tourist often drives a stocked camper and stays in campgrounds. There is not much recreational opportunity at this time.

Although job opportunities are limited, income levels are healthy. Per capita income and median household cash income are both above state averages with a median income per capita of $7,429.

Even during the economic downturn of 1975, unemployment was only 7.7 percent. Employment opportunities are most numerous in semi-skilled and unskilled categories but professional jobs remain scarce. The trades, services and government sectors show cutbacks whenever there is a slight economic downturn.

The services provided in the county are typical for a county with a small population and limited tax base. The per pupil school costs are about equal to the state average, partly because of the small school age population and high operating costs. Expenditures per pupil were $1,248 in 1972-73. The county's health budget is about average for the state. However, the health center in Burns lacks adequate facilities and is scheduled for modernization. There are no special health projects in Burns, but there is a relatively large mental health budget for the county.

Only a few service organizations are available to county residents as compared with most county organizations and reflects the long distances separating residents of Harney Coutny.

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Attitudes and Expectations

Harney County began as a cattle ranching area and has remained such since its early days. But today, in order to survive, ranches require larger acreages and equipment investments than ever before. When it was introduced in the 1930's, the lumber industry brought diversification to the county's economy and will remain a stable element of the economy, but with little future growth.

Because of the lifestyle of hard physical labor, Harney citizens have developed an attitude and value system based on the work ethic and selfsufficiency. As cattlemen and farmers, they see themselves as vestiges of the American pioneering struggle to

survive. In them, the traditions of the old west still remain, and they, like their ancestors, would struggle to protect their way of life. However, potential conflicts may arise because of the growth of the recreation-tourist industry. The tourists are seen as "outsiders" to the local people and they feel that these outside influences may erode their values and way of life.

Special interest groups have become an influential force, particularly in the areas of BLM management actions. The special interest groups probably neither support nor oppose the majority of BLM decisions unless the specific action affects their interests or livelihood. Their involvement may then become substantial.

It is difficult to assess the public's attitudes and expectations about geothermal leasing in Harney County because of so little exploration activity and the lack of understanding about geothermal energy. However, some 80,939 hectares (200,000 acres) have been leased by landowners in the Harney Basin. Their interest is to obtain an additional source of income.

Since geothermal activity is so limited in the county, energy development is not discussed in the "Comprehensive Land Use Plan" published by the Harney County Planning Commission in 1972. Nevertheless, the policy of the Planning Commission is a reflection of the county's attitude toward any future development in the county. The policy of the Planning Commission is:

1. To preserve an environment that will encourage and enhance existing and future industries, thus maintaining a continuing and vigorous economic expansion of the industries involved.

2. To encourage new industries compatible with the natural resources to develop within the county, consequently located and compatible with their needs and available resource. However, it is essential that the Harney County Planning Commission maintain an orderly and systematic use of all resources, thus assuring wise land use planning.

3. To encourage commercial development in concentrated clusters rather than strip areas along streets and highways.

4. To encourage commercial and industrial development to design an attractive construction so as to be compatible to the surrounding businesses and uses.

5. To encourage commercial facilities to locate within present or planned water service areas.

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Local Regulatory Structure

A Harney County planning and zoning ordinance that guides development outside the incorporated communities of Burns and Hines was adopted in 1971. This ordinance has classified most of the study area as an agricultural zone, which is described as "extended to preserve certain land exclusively for agricultural and related uses which land while so used is exempt from zoning and land use regulations." This ordinance also states that it will prevent intensive development in areas where proper community services are not readily available. where certain activities would be in conflict with an orderly development of suburban areas, or where agricultural and related operations constitute the most appropriate use of the land.

Geothermal operations are mentioned as one of the conditional uses of the land under this ordinance. The county planning commission, which is composed of residents appointed by the court, regulates these conditional uses on a case-by-case basis.

III. ANALYSIS OF THE PROPOSED ACTION

A. Anticipated Environmental Impacts

Introduction

This section describes the anticipated environmental impacts of geothermal exploration and development activities on the components which were identified in the previous chapter. The three major phases of the development of a geothermal field-exploration, development, and production comprise a step by step procedure with each phase dependent upon successful indications in the previous phase. Nevertheless, each succeeding phase is a more land intensive operation with the degree of environmental impact greater than in the previous phase. Many of the impacts discussed in this chapter would occur only if federal and/or state requirements were not met.

Exploration

Exploration operations may involve no physical presence on the ground such as airborne remote-sensing photography, or surface exploration which may include both casual use or a more land intensive use. Examples of casual use include geologic mapping, hydrogeochemical sampling, or geophysical techniques such as micro-seismic recording. More land intensive uses include the drilling of shallow temperature gradient holes which may disturb an area of 9 x 9 m. (30' x 30') or a deep exploratory well which involves the construction of new roads and clearing of an area 0.4 to 0.8 hectares (1 to 2 acres) for a drill pad.

Many shallow temperature gradient holes have been drilled by various groups on several of the proposed lease areas. Observation of the operations showed that little damage was done to the environment and what little damage was observed is not now detectable.

As for a deep exploratory well, the constructing of an access road, clearing the drill site pad, and moving heavy equipment would cause some air pollution. These activities may also result in destruction of vegetation, soil compaction and erosion, and a decrease in water quality.

Vehicle and heavy equipment traffic over unsurfaced roads during dry weather would raise heavy clouds of dust. The machinery would produce exhaust fumes, particulate matter and oxides of sulfur, nitrogen and carbon.

Any surface disturbance such as the construction of roads or drilling sites means adverse impacts on the vegetation. As heavy machinery compacts the soil it reduces the amount of available moisture, which suppresses plant growth. The potential for soil compaction is greatest when the soil is wet.

Soil is perhaps the most adversely impacted resource affected by the exploration phase and later stages of a geothermal field development. When vegetation is cleared, soils become susceptible to erosion. Wind erosion is a particularly acute problem in some areas near Harney Lake, Another problem area is in the portion of the Prather Creek area where spring thaw results in an extremely saturated soil condition. Any vehicle attempting to cross this area in the spring would become buried.

The primary impact on water might be an increase in sediments in streams. Building roads and clearing operational sites could intensify siltation, especially if roads were hastily constructed by bulldozer and streams forded by heavy equipment.

Siltation can form barriers in streams and when the barrier breaks, then suddenly rapid flow can sharply increase the suspended sediment load.

If there are significant archeological sites in an area of surface disturbance, the impacts would be direct. It would mean not only loss of artificial materials, but destruction of site stratigraphy. Site stratigraphy is imperative for archeological studies. Surface sites are particularly vulnerable as merely clearing an area for a drill pad may completely remove the site.

There are also indirect impacts on archeological values from the associated geothermal exploration. New or improved roads would provide access to the sites. Consequently, more people, including amateur collectors, would invade the area to collect aftifacts. this "pothunting" is one of the major causes of site destruction in the United States. Only the areas not readily accessible to the public have escaped this type of damage.

However, positive impacts may result from an archeological survey and salvage performed on previously undiscovered areas because of a stipulation added to the leases which require an archeological survey where there is to be surface disturbance. The increase in archeological knowledge gained may outweigh the didsturbance of site areas that are at present unprotected from vandalism.

Certain geologic hazards can be associated with drilling. Geothermal fluids being withdrawn without a concomitant reinjection

of fluids will leave an underground void. The surface above the void because of lack of support may collapse and cause surface and structural damage. Ground water aquifers may be destroyed.

The diesel generators used in drilling an exploratory well would cause some air pollution in the form of exhaust emissions. The greatest threat to air quality is the venting of an exploratory well if steam is encountered. The well must be vented to evaluate the characteristics of the geothermal reservoir. Non-condensible gases, such as carbon dioxide, methane, hydrogen, nitrogen, argon, carbon monoxide, hydrogen sulfide, radon, ammonia, and vapors such as boric acid are often associated in varying amounts with steam from geothermal sources. These gases and vapors constitute less than 3 percent of the total steam fraction. Although these may be present in small amounts they may pose possible pollution and health hazards. Of all these gases, hydrogen sulfide ranks as the most prominent potential environmental hazard. If hydrogen sulfide accumulates locally from a geothermal operation during stagnant air conditions, it could reach a mildly toxic level as well as other gases and vapors. This could adversely affect humans, vegetation, and wildlife.

Some ground water aquifers may be penetrated by the exploratory drilling. If the wells are not properly cased, according to both federal and state regulations, geothermal fluids, which may contain any number of toxic chemicals, could contaminate the ground water supplies. Effects of ground water contamination may be difficult to detect if the aquifer intersected a stream a long distance away or if a ground water pumping well were far from the producing well.

Exploratory wells would have minor impacts on most animal species and habitat because of the small area that is disturbed in the operation. Some impact would involve the temporary displacement of most species of wildlife. Clearing of vegetation, road construction and human activity and noise are important factors that would lower the quality of wildlife habitat on the exploratory well sites. Improper construction methods may cause erosional problems that would result in the deterioration of water quality and loss of fish and wildlife habitat. During exploratory drilling, geothermal fluids which may contain contaminants may be brought to the surface. If not contained properly, the pollutants could kill aquatic life and habitat as well as other species.

Of particular concern is the area adjacent to the Malheur Wildlife Refuge. Many species of waterfowl inhabit the area and any type of accident such as a spill or blowout would endanger these birds and their habitat. The disturbance caused by man's activities and machinery operation adjacent to the Refuge, especially during nesting season, will cause these birds to vacate the area. Other species of birds will also be affected.

Fluids produced during the drilling including the chemicals added to the drilling mud can damage water, soil, and vegetation. These toxic solutions can kill vegetation by direct contact or indirectly by making the soil sterile and unhabitable for plants. If the fluids escape and enter the watershed, dependent fauna and wildlife would also be jeopardized by the contaminated water.

Recreation use would be hampered somewhat by geothermal exploration. With increased human activity some forms of hunting, particularly bird and big game would be impaired. Moreover, an exploratory well would impair the scenic quality of the Desert Trail. The public visitation and use at the Buena Vista scenic overlook would be affected by exploration near the station, as wildlife would probably locate the area. In addition, noise and the sight of exploratory equipment would degrade the aesthetics of this area.

The twenty to twenty-five persons needed in the exploratory phase of deep drilling would add revenue to the local community. It would add a small burden on the community to provide services and goods. If the exploratory phase is unsuccessful, the effects would be temporary.

Field Development

Many of the circumstances described in the exploration section are also true for the development phase, but the impacts become proportionately greater. Because there are many more wells drilled, roads and pipelines constructed, there is more land disturbance and its associated possibilities of soil erosion, vegetation removal, air and water pollution. These impacts would occur on a larger scale in the development scale. Because the area involved in the development phase is much greater, additional factors must be considered, such as conflicts with traditional land uses. Depending upon the circumstances, an Evnironmental Impact Statement may be required at this time.

The possibility of accidents such as blowouts and subsidence are safety hazards. Geothermal activities would also produce noise, odors, and visual intrusions in undeveloped areas.

This phase of operations would also affect recreational uses and values. Construction of facilities would change the appearance and character of the land. Where development occurred, land would be removed from recreation use. The educational and scientific values as well as geologic features in the Diamond Craters may be adversely impacted if proper constraints were not adhered to. Public access to operating fields, unless closely supervised, could be denied because of the possibilities of injuries and vandalism. Recreational uses that depend on motorized travel, such as fishing, hunting and rockhounding could benefit because of improved access. The resources, however, could be adversely impacted by increased people pressure, for instance, big game populations might be reduced by poaching as a consequence of improved access.

Because of the size of the area that might be involved in this developmental stage, the potential adverse effect on wildlife also becomes greater. The encroachment of oil and gas development on the habitat of deer, elk, antelope, small mammals and raptorial birds might force them to migrate to other areas. The greatest hazard comes from harassment during crucial periods of nesting, wintering and breeding. Animal populations displaced from an area can be eventually replaced from surrounding ranges provided the habitat remains intact. Destruction of the habitat might preclude repopulation for extended periods. There have been instances of wildlife migrating out of a geothermal field but eventually becoming accustomed to the disruptions and moving back. Unless proper precautions were taken, both mammals and birds may be poisoned by watering from the mud pits or streams contaminated by leaks and spills that may contain toxic fluids. Mud pits might also trap some animals. Leaks, spills, and soil erosion could threaten fisheries and aquatic habitat in streams and reservoirs. Erection of electric transmission lines might endanger migrating waterfowl and raptors.

The noise level for any geothermal field can be expected to increase as a result of the various phases of geothermal activity. Movement of trucks, drilling of wells, venting of steam and construction activities all tend to raise the background noise level.

An additional health and safety hazard is introduced during field development. Asbestos, alone and in combination with fiberglass, is used as an insulating material around pipelines, as sheathing on cooling towers and for various other uses. If concentrations of airborne asbestos accumulated in enclosed fabricating or storage areas, the fibers could be inhaled by workers, posing a health hazard.

The impact on water supply during development phase will be significant. This is particularly true where water must be introduced in a hot dry rock system to produce steam, as in the Diamond Craters area. Possibility of water pollution or blowouts due to failure of casings and/or cement jobs, exists at wells that have been completed and then shut in before connected to a power plant. It is also possible during this period for a casing leak or poor cementing job to go undetected allowing steam and fluids to migrate into shallow aquifers.

With the substantial increase of people and families during this, the increased demand for housing and trailer rental space, contractor services, and demand on commercial businesses, schools, and city and county government will be significantly increased. Much of the work involves semi-skilled labor. Most of the laborers will have to be imported from outside the

area. Many people in the labor market may not be readily accepted by the local community. The introduction of a labor force composed of people from different backgrounds, subculture or life styles may cause some tension. There will be impact on governmental services such as garbage pickup, new houses being built in accordance to zoning ordinances to accomodate people, health services, improvement of roads and bridges, etc. The movement of heavy construction equipment and generators, construction supplies and materials, and travel of construction workers will put a burden on the State and County roads and bridges.

Production

Non-condensible gases are vented to the atmosphere during power generation from the gas ejector vents on the condensers and from the cooling towers. Release of such gases can affect air quality in the vicinity of the power plant and, if noxious gases are present in sufficient concentrations, may pose a health hazard to employees at the plant. Any accidental discharge of steam, due to the rupture of pipelines or a well blowout, will yield gases and vapors to the atmosphere.

If sump ponds or other impoundments are required during operation, the possibility of embankment failure exists. If rupture should occur, soil erosion and pollution will occur. Water quality may also be impacted through the addition of toxic chemicals as well as increased pediment load.

There is a broad range of potential adverse and beneficial effects on water resources which may result from fullscale production. Environmentally significant alterations can occur in the ground water and surface hydrologic regimes, and in the availability of water suitable for human, agricultural and industrial needs. Such impacts could be felt both on the lease areas or over a much larger area. For example, a decrease in ground water availability through water withdrawal for geothermal steam production could adversely affect the whole Harney Basin. Conversely, the use of electric power from a geothermal field which produces both steam and hot water might also produce fresh water as a byproduct which may beneficially serve a community, agriculture, or industry.

Subsidence of the ground surface would reach a maximum rate during full-scale production unless replacement fluid is returned to the reservoir. In most instances, it may be practical to re-inject the geothermal fluids after utilizing most of their heat.

Impacts on wildlife and their habitat associated with the production phase will continue during the life of the plant,

but even here some wildlife will accept such environmental intrusions without serious consequences. The fauna will surely differ from that prior to initial exploration. Certain species may be favored more than others by habitat change. Existing public access will be restricted to reduce hazards to the public with an accompanying reduction of hunting and other recreational opportunities on these lands. Power distribution lines may cause mortality of waterfowl, eagles, hawks, and other birds from collision and/or electrocution.

The by-products potential of some geothermal developments is expected to be of commercial interest. Heat may be extracted from geothermal fluids for purposes other than power generation, thereby increasing the overall thermal use efficiency and precluding the need for providing alternative sources for energy. It may be also feasible to extract valuable chemicals and potable water from the brines produced. Such by-products can represent positive, beneficial environmental influences.

The demand on governmental services, schools, housing, commercial businesses, hospitals, and health services will decrease during the production phase. People of the county will be receiving benefits from development through perhaps lower taxes as a result of the increased tax base on geothermal facilities. The increase of available electric power and heat extracted from geothermal fluids may increase industrial and agricultural growth in the area.

Adverse affects on the landscape will decline during this stage since there is less equipment, people and distrubance. However, the open space character of the land will have changed because power plants and transmission lines will result in a high degree of contrast in the visual environment.

Other impacts as discussed previously under field development such as contamination of ground water aquifers, blowouts, etc. may also occur during the production stage. Studies would be required prior to approval of operating plans and the operation monitored to determine the impacts and reduce them if possible.

Abandonment

This phase has the least impact on the natural environment. It might not be possible to reclaim the disturbed sites and restore them to their original condition. However, all facilities would be taken down and measures to reclaim the land to as near as the original condition would begin as soon as possible.

B. Possible Mitigating Measures

Introduction

A tract of land is not offered for oil and gas leasing unless the environmental analysis indicates that the anticipated impacts as identified in the previous section, can be mitigated. The following section is a description of the methods that could be employed to reduce or allevaite those anticipated impacts.

General

Mitigation of potential environmental problems and impacts stemming from geothermal exploration and development activity can be accomplished through enforcement of applicable federal, state and local laws and regulations, geothermal exploration and leasing regulations, geothermal operating regulations, Geothermal Resources Operational (GRO) Orders, lease and land-use permit stipulations, and application of existing and developing and yet to be developed technologies.

Although the number of geothermal installations in the world is limited, a great amount of technical and operational information has been gained from them. Certain technologies, such as drilling methods and handling of high pressure fluids, have been directly transferred with appropriate modification, from the petroleum industry to the geothermal industry. Our knowledge of environmental causes, effects and remedial or preventive measures specifically relating to geothermal development ranges from adequate to limited. Some environmental impacts are known and can be prevented; some impacts can be anticipated and adequate environmental protection can be planned; some impacts can only be hypothesized so contingencies included under the general regulations may provide a means for corrective action in the event these impacts become reality. If unacceptable environmental factors exist which cannot be corrected, development or operation would not be permitted.

If a significant geothermal resource is discovered, one involving two or more power generating plants, it is probable that development will occur over a period of years. This probable prolonged development period of itself tends to be a mitigating measure in that problems discovered in initial operations may be solved and taken care of in succeeding operations. If problems develop which cannot be satisfactorily solved, the regulations provide for shutdown of operations until such time as acceptable corrective action is taken.

Exploration

Section 3209.2 of the Geothermal Regulations provides that no exploration operations will be conducted on public lands except pursuant to the terms of a Notice of Intent which has been approved by the authorized officer. Section 3209.1-1 sets forth the requirements for filling such a notice. Special provisions relative to the particular area involved will be included as appropriate to assure adequate environmental protection in connection with such exploratory operations.

Monitoring

Monitoring of potential impacts related to exploration, development and production of geothermal resources is a requirement under Federal regulations. Such impacts include noise, air quality, water quality, radioactivity, erosion, fish and wildlife and land subsidence.

Monitoring of noise, and air quality, which are readily identified and associated with specific activity on an individual lease, will be the responsibility of the lessee, under the supervision of the U. S. Geological Survey and will be required as a stipulation in the lease or through Geothermal Resources Operational (GRO) Orders.

Monitoring of changes in water quality, sediment yield, fish and wildlife values, erosion and land subsidence will be the responsibility of the Department of the Interior.

Land Resources

The term applies to those surface oriented activities and operations affecting the surface such as aesthetic values, erosion control, and land stability problems.

Section 3204.1 (f) of the Geothermal Regulations requires that aesthetics be taken into account in the planning, design, and construction of roads, pipelines and facilities. Careful planning, design, and supervision of operations should lessen the undesirable impact of such operations. The overall impact will be lessened if operations can be conducted out of sight of main public access routes. Facilities should be blended into the background as much as possible to minimize the contrast with the natural setting. Power plant buildings should be designed with minimum profiles. Facilities and pipelines should be camouflaged by proper selection of paint color. Roads should be constructed to minimum necessary width and as much as practical following the natural contour.

All of the public land in the EAR area is managed under the multiple use concept involving such uses as recreation and grazing. The principal measures assuring multiple use of the surface are contained in Section 3204.1 (b) of the Geothermal Regulations which assure public access to leased land and limits restrictions on access by the lessee to those consistent with health and safety requirements. Lands in the vicinity of wells, pipeline, and power plants must be restricted from hunting and general access in the interest of safety. Fencing will be required at hazardous locations.

Livestock grazing and geothermal operations should coexist satisfactorily with proper planning as required under Section 3200.0-8(b). Examples of actions which can be considered to insure minimum impacts on grazing include:

1. Livestock management facilities including fences, cattle-guards, pipelines and water troughs will be repaired or reconstructed if they are damaged by geothermal exploration or development.

2. Fence mud sumps and other areas which might endanger livestock.

3. No developments or drilling within one-quarter mile of all livestock watering facilities including reservoirs, troughs and wells.

Erosion Control

Section 3204.1(c)(4) of the Geothermal Regulations requires minimum disturbance to vegetation and natural drainage. The lessee will be required to employ adequate conservation practices on the leased land. Compliance will also alleviate potential downstream impacts from increased sediment load. Stream sedimentation may also be regulated by state water quality authorities. Mitigating measures include reseeding of disturbed areas, dust and erosion control on roads, well sites, and construction areas, and sound engineering practices in construction of roads, drill pads and structures. Examples of mitigating measures which will lessen environmental damage are:

1. Road and trail construction shall not block drainage systems or water courses. Culverts or other suitable crossings installed on drainages and the road drained or water barred as necessary to prevent erosion.

2. The slope of cut banks and fill slopes shall not exceed $1\frac{1}{2}$:1.

3. Down spouts should be provided where culvert drains may cause fill cutting and accelerated erosion.

4. All roads planned for permanent or long duration use should be adequately gravelled or paved to control erosion.

5. All access roads and trails, drill pads, etc., will be rehabilitated as soon as possible after abandonment.

6. All disturbed areas should be re-vegetated for adequate soil protection.

7. The top soil on disturbed areas on sites other than for permanent construction shall be stockpiled for use in reclaiming the sites.

8. Sufficient buffer strips of natural vegetation should be left between disturbed soil and drainage bottoms to aid in preventing sediments from moving into a stream.

9. Harmful chemicals should be removed from all sumps and ponds. Upon abandonment, sumps and ponds should be filled and re-vegetated.

10. All rehabilitation measures should be directed toward restoring the area to as near natural condition as possible.

11. Soil disturbance shall be kept to a minimum (vehicle travel will be restricted to roads as much as possible).

Other Land Use Factors

Disposal of waste will be regulated as prescribed by Section 3204.1(a). Mitigating measures which will lessen environmental impacts are:

1. Comply with applicable federal, state and local sanitary and waste disposal regulations.

2. Remove all garbage waste and foreign debris from the area.

3. Any human solid waste will be disposed of through chemical or gas fired toilet facilities on drilling site(s). Suitable sanitary facilities should be provided in power generating plants and other permanent installations.

Air Quality

General provisions for prevention of air pollution and related employee health and safety are included in Sections 3204.1(c)(3), 3204.1(c)(5), and 3210.2-1 of the Geothermal Regulations. Examples of mitigating measures which will lessen environmental damage are:

1. Dust - Dust will be generated by movement of vehicles, construction activity and test drilling. To minimize dust generation, the lessee will be required to:

   a. Keep new road construction to a minimum.

   b. Limit site disturbance in pad and building construction to the smallest area necessary for satisfactory development and use.

   c. Gravel or pave all access roads and trails receiving heavy use.

   d. Gravel or pave all power generating sites.

   e. Control dust, when air drilling by whatever means necessary.

   f. Although not related to dust, require workers to wear protective devices when working with asbestos and fiber glass to prevent breathing airborne particles.

2. Noise - Noise due to steam ejection or expansion, drilling operations, construction activity, and other related geothermal activities may pose serious health and environmental hazards. To minimize adverse environmental effects from noise generation, the lessee should be required to:

   a. Comply with federal and state noise exposure levels established pursuant to the Occupational Safety and Health Act of 1970.

   b. Install the latest muffling equipment on both wells and drilling rigs.

   c. Limit drilling and production so that no geothermal wells are located closer than ½ mile to any populated area (10 or more dwellings within ¼ mile area) without written consent of 75% or more of the owners. In addition, the following minimum distances should be observed in locating a well in areas other than populated areas:

      (1) Outer boundary of parcel - 100 feet
      (2) Public roads - 100 feet
      (3) Residences or other development - 500 feet

3. Gas & Vapors - The venting of steam to the atmosphere can create an adverse environmental impact if the steam contains significant amounts of noxious gases. To protect environmental values, the lessee should be required to:

   a. Comply with national and state primary and secondary ambient air quality standards, as well as safety and health standards when releasing gases and vapors to the atmosphere.

   b. Limit emissions from venting wells or pipelines to short durations.

4. Burning - Burning of trash could contribute to significant air pollution. It is recommended that no burning be permitted.

   To insure that wild fires do not result in environmental degradation, the lessee should make every effort to prevent, control or suppress any fire within the lease. Reports of uncontrolled fires must be immediately sent to the BLM's District Manager or his representative.

   The lessee will be responsible for any fire suppression costs that are determined to result from his operations.

Water Quality

To prevent any deterioration in quality of either surface or subsurface waters, the following measures should be implemented:

1. Comply with federal and state water quality standards.

2. Waste waters will not be discharged into live streams or underground aquifers, except that waste waters may be reinjected into the producing reservoir from which it was withdrawn.

3. Toxic materials will not be released to any surface waters or to any subsurface waters that are suitable for irrigation, livestock, or human use.

4. No discharges to surface water which would result in increasing the sediment load above acceptable limits will be permitted.

5. Cementing and casing during drilling and production will be adequate to prevent contamination of fresh water aquifers.

6. Monitoring will be adequate to prevent casing leaks or cement job failure from contaminating aquifers or resulting in blowouts.

Wildlife and Wildlife Habitat

Section 3204.1(g) requires the lessee to employ such measures as deemed necessary to protect fish and wildlife and their habitat. Section 3204.1(i) provides that the lessee shall provide for the restoration of all disturbed lands in an approved manner. Necessary fish and wildlife protection and land restoration measures will be developed on a sensitive basis and included as special stipulations in each lease. Such stipulations should include:

1. The proper spacing of high voltage transmission lines should in itself prevent any electrocution of birds. Should local use of geothermal power involve smaller, closer spaced lines, then the specifications for power transmission lines developed by Mr. Morlan Nelson, Birds-of-Prey consultant, in consultation with Idaho Power Company and the Bureau of Land Management should be applied. Mr. Nelson's designs are attached in Appendix B.

2. All surplus brine and associated effluents should be reinjected into the appropriate strata to prevent the possibility of contamination of the local and regional watershed.

3. Areas of vegetal removal and/or soil disturbance should be seeded or planted to native vegetation. Plant species not native, such as crested wheatgrass, nomad alfalfa, etc., might also be utilized where adapted to the sites.

4. Noise suppressing mufflers must be installed on vents to minimize the adverse effect of operational noise on wildlife.

Parts of the Prather Creek area and Diamond Craters cannot have vegetation damages mitigated due to the lack of soil. Travel off road should be held to an absolute minimum, as should all forms of vegetation disturbance.

Water is sparse throughout the area. No water should be withdrawn from water sources on NRL.

Habitat types containing bitterbrush should be planted to bitterbrush seedlings as well as herbaceous species and temporarily fenced off to keep livestock out. These areas will likely be small enough so there shouldn't be much tendency for deer to get in them. A 6 foot net wire fence should discourage deer in the area to be planted/seeded in the spring.

No surface occupancy or exploration should be allowed within 200 yards of water.

Transmission lines should be designed to prevent raptor electrocution and when possible install perches to improve raptor habitat. No surface disturbance or occupancy should take place on special animal use areas as follows: within ½ mile of sage grouse strutting grounds, March through May; within ½ mile of eagle nests, February through August; within deer winter range, December through April.

Pipelines and other barriers constructed in deer and antelope range should be designed to allow free movement of animals.

Mitigating measures pertaining to water quality and subsequent effects on aquatic organisms are covered in applicable lease stipulations and state water quality laws.

No drilling or blasing within ½ mile of perennial water on National Resource Lands, Malheur Wildlife Refuge, or the pond in T.27S., R.30E., Section 36, from March through July to protect nesting aquatic birds. If artesian flows are encountered, they will have valves attached. This water could benefit wildlife and livestock.

All sumps to be fenced with 3 inch net wire around and over them to keep wildlife from being trapped. Sumps will be filled following their use.

Human Values

Other than apprising the lessee of county and city zoning ordinances, building codes, etc., and requiring him to comply with local laws, the only method of mitigating impacts of geothermal exploration and development on Human Values (owners of private land and the people in general) is advising the county and city governments of the potential impacts so they in turn may advise the local citizenry. The mitigating measures required to forestall problems created by a temporary (but possible long term) influx of 30 to 200 people and families will have to be initiated and accomplished by county and city governments and local businessmen and citizens.

Archeological values would be directly impacted by any surface disturbance. Our knowledge of the cultural resource values in the lease area is imcomplete. To alleviate the inadvertent destruction of the unknown cultural resources of the area, the lessee could be required to hire a certified archeologist to survey the area prior to surface disturbance. The purpose of the survey would be to disclose the existence of antiquities and other objects of interest.

Abandonment

During abandonment of a field, drilling pads, well sites, storage sites, roads, etc., could be ripped and revegetated as soon as oil structures are removed. If any area shows evidence of soil compaction, the area could be ripped and revegetated. Reclamation of abandoned well sites and producing fields could include revegetation of disturbed areas with plant and grass species beneficial to wildlife. Mud pits could be allowed to dry before the pit is filled in and graded to as near the original surface as possible and replanted. Abandonment wells could be sealed as required by the U. S. Geological Survey and the State of Oregon Regulations.

C. Recommended Mitigating Measures

If the geothermal leases are issued, the lessee must operate under the Geothermal Resources Operational Orders. The lessee must also comply with the requirements of the Environmental Protection Agency (EPA) for air and water pollution.

The State of Oregon also has jurisdiction over geothermal operation on Federal lands. The lessee must comply with the regulations set forth by the Department of Geology and Mineral Industries. In addition, the Department of Environmental Quality, The Department of Fish and Wildlife, and the Land Conservation and Development Commission might also have input prior to the development of a geothermal field.

The following stipulations are those recommended to be added to the proposed geothermal leases:

1. All unique zoological, botanical and geologic features in the Diamond Craters area shall be protected from any geothermal exploration and development.

2. Operations within 600 feet of any surface waters or wet soil areas such as streams, springs, seeps, reservoirs or meadows, will be permitted only if specifically approved in writing by the Authorized Officer and the Supervisor.

3. Backfilling, final grading, revegetation and removal of surface supporting facilities shall be completed within one year after completion or termination of the particular operation involved, unless the Authorized Officer extends such time.

4. Prior to any operations under this lease, the Lessee will engage a qualified archeologist, acceptable to the Authorized Officer, to make an archeological survey of the land to be disturbed or occupied. A certified statement, signed by the qualified archeologist, setting out the steps taken in the survey and the findings thereof as to the existence of antiquities or other objects of historic or scientific interest, shall be submitted to the Authorized Officer.

5. The Lessee shall contact the Authorized Officer prior to development of a plan of operation to be apprised of practices that should be followed or avoided in exploration or field development, including but not limited to such matters as road standards, road crossings, gates, cattleguards, fencing, erosion control, surface rehabilitation, reservoirs, wells and springs.

6. The Lessee will apply to the Authorized Officer for a tramroad right-of-way permit pursuant to 43 CFR 2811, <u>over lands and roads owned or controlled by the BLM</u> for the purpose of obtaining access to the leased area.

Additional operational measures for the protection of the environment can be specified in the U. S. Geological Survey - surface management agency joint approval of the plan of operations required for any operation to be conducted under a lease. Here, areas of concern that are specific to the site or sites under consideration may be addressed if it is not already adequately treated under the geothermal regulations or geothermal resources operational orders.

D. Residual Impacts

The geothermal operating regulations, lease provisions, land use planning, permit reviews and other rules and regulations are designed to assure that geothermal operations are conducted in an environmentally acceptable manner. In those instances where this cannot be done, development and use will not be permitted. Where the benefits of a proposed action outweigh acceptance of minor adverse impacts, such uses are acceptable provided the impacts have been identified and mitigated as much as possible. The following summarizes the type of adverse impacts that are unavoidable should the leases be issued and the operations go to completion.

One of the major impacts resulting from the proposed action that could not be avoided is the impact on the local communities. Even with land use planning and local community involvement, the local communities would be affected if the development phase were reached. A possible burden could be placed on

community services to provide housing, schools, water and sewage facilities and health services depending on the size of the field and the rate of development. However, the local communities would also derive some benefits from geothermal development like new schools, roads and hospital facilities as a result of the increase in tax revenue.

The open desert nature of the area covered by this EAR will have been converted to an industrial complex. A resultant change in wildlife species will unavoidably occur. Raptorial birds, pronghorn antelope, and other disturbance sensitive wildlife will permantntly vacate the area. More tolerant species of wildlife, such as the numerous rodents and insects, will continue to occupy areas of suitable habitat. Additional species, not now common to the area may occupy newly created habitat.

The intrusion of structures, pipelines, and transmission lines into this area will create an adverse visual impact. Development will lessen the open space character of the land.

If development were to occur in the Diamond Craters area, educational, scientific, and recreational values would be lost. However, this would depend on where the development would occur in the Craters area.

Like any construction activity, some noise, dust and engine exhausts cannot be avoided. Because of the noise and intrusion of activity, some wildlife will be displaced. Recreational activities will also be displaced because of the potential safety hazards.

Relatively large areas of land leveled for power generation sites will remain. Cuts and fills for roads, steam pipeline routes will also remain visible. However, the combination of restoration and natural revegetation recovery will, over time, result in a near natural setting with possibly only contour change as evidence of prior use. The lands will return to their former productivity or they will be available for other appropriate uses. This is true for all the proposed lease area with the exception of one--Diamond Craters. Depending upon the location of development, educational, scientific, and recreational values may be permanently lost.

IV. RELATIONSHIP BETWEEN SHORT-TERM USE AND LONG-TERM PRODUCTIVITY

The leasing of lands for geothermal resource development involves the commitment of a portion of the geothermal heat, water, and related land areas and resources of the sites involved. It is particularly significant to recognize that the geothermal heat is a wasting resource that otherwise would be dissipated over time from the surface of the earth to the atmosphere with little or no identifiable benefit. By contrast, development of this resource in an environmentally acceptable manner can have substantial benefit by affording a relatively clean power generation energy source.

The exploration and testing phases of geothermal leasing are designed to determine the nature and extent of geothermal resources. Generally the active portion of this phase is of short duration, sometimes extending only over a period of days, months, or at most, a few years. It may be intensive and continuous for short periods or periodic over several years. Where such exploration proves unsuccessful, there will not be subsequent use of the land for development and production of geothermal resources. Under such conditions, leases will terminate at the end of the ten year primary term. However, in many instances such leases will be relinquished by the lessee at an earlier date to avoid additional lease payment costs. Exploration and lease provisions will require that lands disturbed by unsuccessful exploration will be restored as nearly as possible to their original condition upon termination of these activities. Such restoration includes measures such as grading, installing proper drainage, soil stabilization, revegetation, removal of all equipment and supplies, proper removal or disposal of all wastes, filling in of holding ponds, etc. Except for scars from leveling of drilling sites, roads or other major earth movement, the areas should return to natural conditions in a short time. Changes in vegetative cover may result, depending upon whether native or non-native plants are used. Generally the native vegetation will retake the area; however, on some sites aesthetic and vegetative impacts may last over a long period due to the slow natural recovery factors.

Where exploration discloses the existence of economically attractive geothermal resources, the development and production of such resources for electric power generation, and possibly water and mineral by-products can be expected to occur. Timing of such development will depend upon electric power markets, power transmission systems, construction schedules, etc. Once production begins the geothermal resource will be withdrawn at a rate greater than the natural replenishment rate. Over a period of years (perhaps 20 to 25 years, depending upon the nature of the resource province) production capacity will be depleted to the point where further operation will not be economically feasible. When the reservoir is no longer capable of sustaining the geothermal operation, the leases will be terminated, the facilities will be dismantled, and the land will be resotred, insofar as practicable, to its original condition. Most

of the area involved in the operation will have become well stabilized except for the actual areas used for the generation facilities, roads, or other structures or facilities. Removal of improvements will result in some disturbance, particularly in well and steam pipeline areas, but such disturbance will be of a temporary nature and subject to appropriate restoration. Unless the land areas occupied by production facilities were to be used for some subsequent and nonrelated purpose, they will be properly graded, drained, stabilized, and revegetated so that they will again become a part of the natural environment. Relatively large areas of level land will remain, such as the power generator site. Cuts and fills for roads, steam pipeline routes, etc., likewise will remain visible. However, the combination of restoration and natural vegetative recovery will, over time, result in a near natural setting with only contour change as evidence of prior uses. The lands will return to their former productivity or they will be available for other appropriate uses.

The Resource

By developing geothermal resource potentials, a previously unused natural resource will be tapped to help meet the Nation's growing energy needs. In terms of total energy requirements, the contribution of geothermal resources may be relatively small but it can be important, particularly on a local or regional basis. The generation of power will be the principal use of geothermal resources; however, there also is a possibility that by-products of water or minerals might be possible. In many cases the geothermal resources may not be of sufficient temperature to be useful for electric power production but will be useful for space heating, industrial processing or agriculture.

While depletion of some of the heat within the geothermal reservoir will occur over the period of operations, no permanent adverse effect is anticipated. Over time, perhaps a hundred or more years, natural heat transfer within the earth might even return the heat content to nearly the same intensity as existed before utilization. At some time in the relatively distant future it might be possible for such areas to again be used for similar productivity. Any use of by-product minerals probably will represent mineral recovery that otherwise would never have occurred. Such use will preclude the need to obtain a like amount of such materials from other sources. Where waste waters are reinjected, the associated mineral values will be returned to the earth.

Water

The consumptive use of water resources, primarily geothermal fluids, in the power generation or mineral by-product process will constitute a depletion of the gross water resources of the area. To the extent that geothermal fluids are withdrawn from the subsurface reservoir and not replaced by reinjection or natural recharge, the

waters so consumed represents depletion of water in storage. However, in most instances, due to high mineral content, this will be water that otherwise probably would not be used. If subsidence should occur, the water storage capacity of the geothermal reservoir will be permanently reduced but since such waters probably could not be used for other purposes within the foreseeable future, the reduced storage impact may not be adverse in terms of future water productivity.

Geothermal fluids may also be of sufficient purity to be used directly for irrigation or other purposes after the fluid has been cooled. This could provide a source of fresh water during the period of power operation and it is possible that the wells could continue to be used even after power production has ended. In some areas, the geothermal fluids are expected to be concentrated brine which will not be suitable for any other purpose. In such situations, the wells will be sealed upon termination of power generation. The use of such water should not affect water resources available for beneficial use.

Under the proposed controls for waste disposal, degradation of surface and fresh ground waters is not expected to be significant, especially in a long-term sense. Mishaps or accidents may have short-term impacts that, depending upon the volume and nature of discharge involved, could be serious, particularly on aquatic resources. However, corrective measures such as dilution, diversion of waste waters from streams, capturing in impoundments, etc., should provide adequate measures against serious or long-term impacts.

Land

Land uses during the period of production operations will be changed to industrial operations from wildlife habitat, recreation, and grazing. However, many such uses can continue on a reduced compatible basis. Wells, pipelines, power plants, by-product facilities, and power transmission facilities will dominate the local area. Public access in the vicinity of such facilities will have to be restricted to protect the public and the facilities. Development and production of geothermal resources generally are not expected to have any lasting or inhibiting effects on the use of the land after geothermal operations have been concluded and facilities have been removed.

Should geothermal production result in land subsidence, which is an irreversible process, the subsidence constitutes a long-term effect on the land resources. Such subsidence, however, will not significantly affect use of the public land in the area covered by this EAR.

Wildlife and Recreation

Geothermal resource development could result in certain localized adverse impacts on wildlife and their habitat. There could be a loss of wildlife habitat in the immediate vicinity of installations

and minor loss of birds from collision with electric distribution lines. In addition, restrictions of public access will reduce hunting and related recreational opportunities in the vicinity of installations. A change in the natural setting of lands could result in long-range effects on wildlife by rendering some lands less desirable for wildlife habitat purposes. In some instances, wildlife species such as the starling, English sparrow, and American magpie may benefit from development activities.

Economic and Social

Geothermal development requires substantial investment in drilling wells and construction of roads, pipelines, power and by-product plants, and transmission lines. Such investments result in an increased tax base for the area of development. However, the labor-intensive phase may be short-term, occurring primarily during field development, and would result in significant changes in population distribution. The economic benefits probably would have to be developed elsewhere if the geothermal resources were not developed. Generally, the costs for a hot water geothermal plant are comparable to hydroelectric, nuclear and oil fired plants. Dry steam plants are much less costly, but few dry steam sources are expected to be found. Gas fired power plants have a cost advantage but, due to the increasing scarcity of natural gas, continued use of remaining supplies represents a waste of this cleanest of energy resources. Coal fired plants appear to have a cost advantage, provided increasingly stringent air quality standards can be met without significant increases in coal production or utilization processes.

Geothermal resources can be economically competitive where such resources can be developed near existing power systems or where additional transmission costs are nominal. Since the generation capacity at each site may be small, substantial investments in power transmission systems could cause such development to be uneconomic.

V. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The principal commitment of resources is the depletion of thermal energy and water from the geothermal reservoir. Both of these resources are renewable but not within the life span of a specific project. Once they are depleted to the point where economic production cannot continue, production will stop, facilities will be removed, and the area will be restored to as nearly a natural state as is practicable. There is no foreseeable alternative use of the stored energy other than possible space heating. The associated water produced by the operation could be of significant value if it is of sufficiently good quality, either naturally or by desalination, to be used for other purposes.

Compaction and resulting land subsidence that may result from the removal of geothermal fluids can have irreparable consequences. An equivalent amount of water storage will be lost. In developed areas, substantial adjustments might be required to compensate for such subsidence. The EAR area borders developed land and in many cases is separated by irrigation canals. Subsidence in these areas could cause breaching of the canals. This would cause considerable damage to the developed land below. On the land in the EAR area, however, no adjustment will be required from such a phenomenon. If seismic action results from fluid withdrawal or reinjection, considerable damage could result, depending upon the severity of the action.

Some onsite or related ecological features such as plant life, wildlife, and aesthetics can be altered. Cuts and fills for power plant sites, production wells, roads, etc., can leave landscape scars. In some instances, roads may be retained as permanent access routes to facilitate other land uses. The extent of such alterations depends upon the indivisual site and the nature of development.

Dedication of the land surface to industrial uses generally will result in land areas being used for wells, associated surface facilities, power plants, roads and transmission lines. While not of a permanent nature, such uses represent a commitment for a period of 25 to 50 years. This is relatively a long period in terms of human lifetimes and related alternative uses of these lands and their other resources.

Human energy, money and construction materials are other resources irretrievably committed in the development of geothermal steam. However, to the extent that these resources represent a commitment to increased power generating capacity to meet regional or national needs, their consumption would be necessary regardless of the technology utilized in the generating process.

VI. PERSONS, GROUPS, AND GOVERNMENT AGENCIES CONSULTED

Appendix C is a list of people and agencies consulted on the proposed action and the Environmental Analysis Report.

VII. INTENSITY OF PUBLIC INTEREST

Letters were sent to interested parties (Appendix C). Very few people responded to the letter. The people who did respond were particularly concerned about the Diamond Craters area.

VIII. PARTICIPATING STAFF

This Environmental Analysis Record was prepared in the Burns District, Bureau of Land Mangement by:

Bob Pulfrey, Geologist
Ruth McGilvra, Archeologist
Guy Sheeter, Wildlife Biologist
Dick Miller, Realty Specialist
Lisa McNair, Soils Specialist
Dave Vickstrom, Recreation Specialist
Larry Todd, Natural Resource Specialist
Jon Durham, Geologist, U.S. Geological Survey, Menlo Park, CA.

IX. SUMMARY CONCLUSION

It is unlikely that work beyond the exploration stage will occur on most of the area which has geothermal lease applications. Exploration has the least environmental impact of the stages of geothermal development. Therefore, most of the area will not have residual impacts, changes in short-term use or long-term productivity, or any irreversible and irretrievable commitment of resources.

The area in which geothermal development occurs will be removed from production for some resources for an indefinite period of time. This area will experience residual impacts, changes in short-term use and long-term productivity, irreversible and irretrievable commitment of resources, and an increase in public interest.

Should geothermal development take place, another environmental assessment will be needed to examine the impacts on the site of development.

The principal irretrievable commitment of resources would be the depletion of the geothermal resource. Once the resource has been depleted, the area would be restored, as nearly as possible, to the natural condition.

If development were to occur in the Diamond Craters area, educational, scientific and recreational values could be adversely affected. Public interest in leasing of Diamond Craters is high, while interest in other areas under discussion is low.

APPENDIX A

SUPPLEMENTAL GEOLOGIC REPORT

By:
Jon Durham, Geologist
U.S.G.S.

HYDROLOGICAL INPUT TO THE HARNEY LAKE
ENVIRONMENTAL ANALYSIS RECORD FOR
PROPOSED GEOTHERMAL LEASING

by

Jon A. Durham

Office of the Area Geothermal Supervisor
United States Geological Survey
Menlo Park, California

LOCATION

The seven areas being considered for geothermal leasing lie along the periphery of the Harney Basin, an enclosed drainage subdivision located in Harney and Grant Counties of southeast Oregon (Fig. 1). The Prater Creek, Willow Creek, and Burns Butte (KGRA) geothermal areas are situated in the northwest quarter of the basin, just north and west of the town of Burns, and the West Harney Lake, Harney Lake, Jackass Butte, and Diamond Craters geothermal areas lie within the southwest quadrant, near the southern limit of the basin.

LAND FORMS

The Harney Basin covers an area of approximately 5,300 square miles (13,700 Km^2), and is both a structural and erosional feature, consisting of two basic land forms; 1) approximately 800 square miles (2,000 Km^2) of lowlands dominated by alluvial plains, lake beds, cinder cones, and lava fields; and 2) high marginal areas composed of exposed equivalents of the concealed valley foundation. The nearly flat alluvial valley bottom slopes as much as 400 feet per mile (7.5 m/Km), although the main valley reveals only a 2-7 feet per mile (.4 to 1.25 m/Km) gradient (Piper and others, 1939). The bordering highlands dominate the basin margin, and except along the southwest perimeter, form very definitive boundaries either through abrupt contact, as in the northern part, or gradually, as exempified by the dip slope of Steens Mountain to the southeast. All the geothermal units cover parts of the bordering highlands directly adjacent to the lowlands where relief is rarely over 1,000 feet (300 m) above the valley floor.

Overall, relief of the basin is about 5,500 feet (1,700 m) as elevations of the highlands vary up to 9,600 feet (2,926 m) at Strawberry Mountain to the north and 9,400 feet (2,865 m) at Steens Mountain to the southeast.

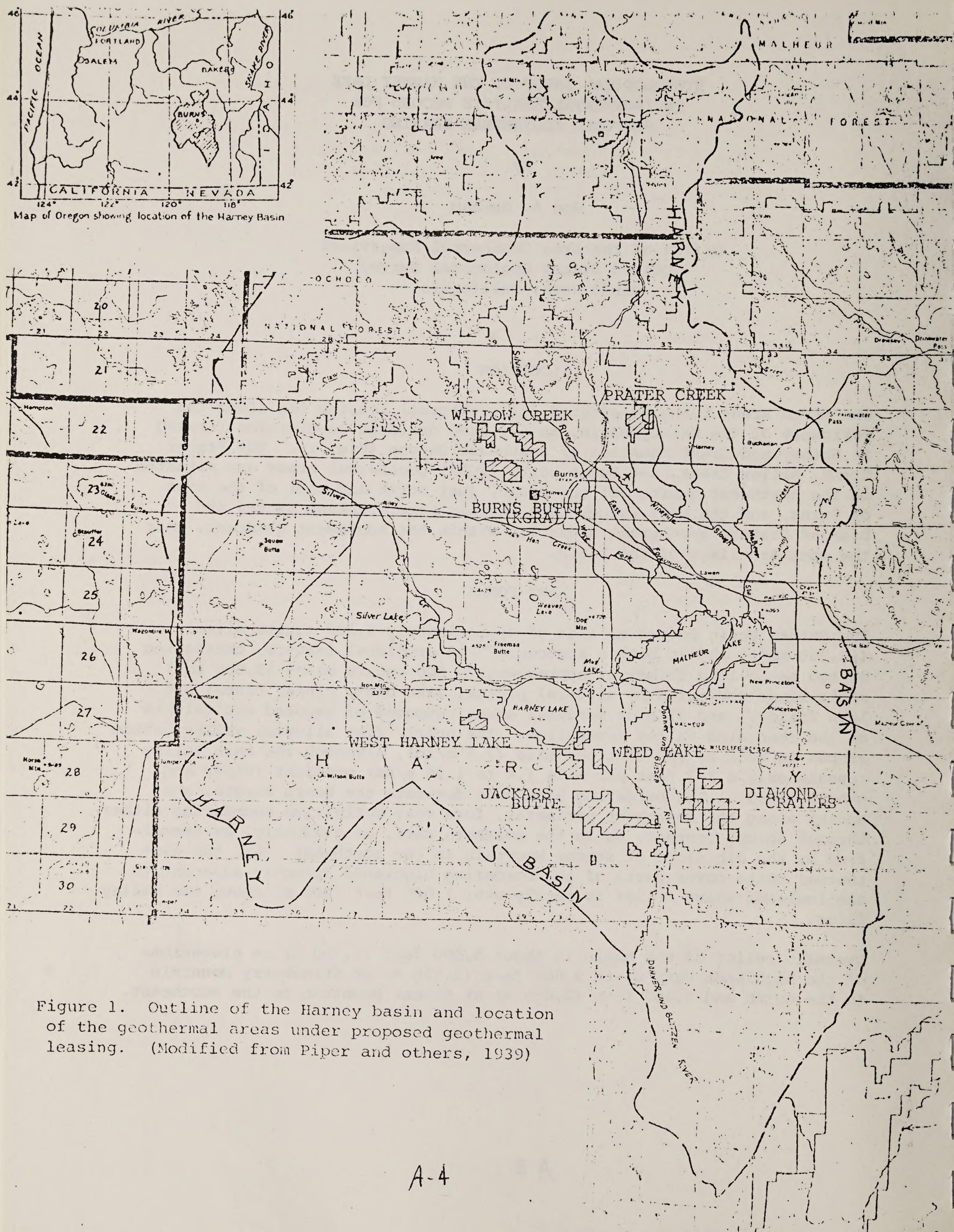


Figure 1. Outline of the Harney basin and location of the geothermal areas under proposed geothermal leasing. (Modified from Piper and others, 1939)

GENERAL GEOLOGY

The Harney Basin lies within the Basin and Range province and is composed of non-marine Tertiary and Quaternary strata resting on a basement of Lower Jurassic crystalline and metamorphic rocks (Table 1). The Tertiary deposits are comprised mostly of: 1) extrusive basalts, andesite and rhyolites; 2) volcanic ejectamenta ranging in composition from massive tuff to breccia; and 3) detrital sediments of alluvial and lacustrine origin (Piper and others, 1939). According to Piper and others (1939), in ascending order these rocks include older siliceous extrusives and Steens Basalt of Miocene age, and the Danforth Formation, a fanglomerate near Coffee Pot Creek, and Harney Formation of Pliocene age. These units not only intercalate but grade laterally into one another in a complex fashion.

The majority of the Quaternary deposits include 1) terrace deposits and basalt and basaltic ejectamenta of Pleistocene age near Voltage and Hines, and 2) unconsolidated fill and contemporaneous basalt of Pleistocene and Recent age near Diamond (Piper and others, 1939). These volcanic and sedimentary units are also believed to interfinger.

All the Tertiary and Quaternary stratigraphic units are thought to either transmit, contain, or both transmit and contain water (see Table 1). In addition to information in Table 1, the older siliceous rocks and Steens Formation are reported to constitute erratic, unpredictable aquifers at the eastern Crow Camp Hills (Leonard, 1970). Overall, the Danforth and Harney Formations are capable of transmitting and yielding large quantities of water, although in places, its tuffaceous and clayey members are poor aquifers, as thought to be the case of the upper part of the Harney Formation at Wrights Point and adjacent highlands south of Sage Hen Creek (Leonard, 1970). The younger basalt near Hines and south of Voltage are considered quite permeable and capable of acting as productive aquifers. The valley fill, one of the more important sources of water, transmits and contains water in various sands and gravel layers which are thought to interconnect.

DRAINAGE SYSTEM

Left unimpeded, precipitation which enters the Harney Basin travels toward the lowermost part of the enclosed structure, Harney Lake (Fig. 1). This water is carried either on the surface or underground. Streams, generally following dip slopes and faults, flow from the bordering highlands and provide most of the basinal waters. As the basin constitutes a closed system, evapotranspiration is the only method of water removal.

Geologic age		Formation	Thickness within area represented by plate 2 (feet)	Character and extent	Water-bearing properties
Tertiary.		-Unconformity?			
	Pliocene.	Danforth formation.	20–800+	In vicinity of Burns comprises (1) an upper part that includes a distinctive rhyolitic tuff-breccia member, also stratified siltstone, sandstone, tuff, and volcanic ash with layers of glassy or perlitic rhyolite at a few horizons; (2) a lower part made up of massive rhyolite, commonly spherulitic.	Upper part yields considerable water to municipal wells at Burns and Hines but was not water-bearing in a well near Prater Creek; lower part yields thermal water locally from fault conduits.
				In district south of Harney Lake comprises (1) the distinctive tuff-breccia member and associated rocks; (2) an equally distinctive basaltic-breccia member and associated siltstone, sandstone, and conglomerate and two intercalated layers of basalt; (3) stratified siltstone, sandstone, and ash; and (4) spherulitic rhyolite.	Yields considerable thermal water to large springs along fault conduits; sedimentary members inferred not to be water-bearing at a distance from the faults.
				All sedimentary members semiconsolidated; local unconformities between certain facies; crops out extensively in marginal upland.	
		-Unconformity-			
	Miocene.	Steens basalt.	0–1,500+	Basalt, layers average 10 feet thick, scoriaceous and fragmental zones common at top of each layer; andesitic facies locally; crops out in marginal upland along eastern half of the basin.	Scoriaceous and fragmental zones, together with fault fractures, have considerable water-yielding capacity locally; in Donner und Blitzen Valley supplies several perennial thermal springs along fault conduits.
		-Unconformity-			
	Miocene (?).	Older siliceous extrusive rocks.	1,000+	Rhyolite, commonly massive and spherulitic with glassy groundmass; generally crumpled and faulted; forms a few scattered masses, mostly in eastern half of basin.	Presumably pervious only along fractures.
		-Unconformity-			
Jurassic (in part).	Lower Jurassic (in part).	Pre-Tertiary rocks undifferentiated.	(?)	In northern part of basin fossiliferous limestone of Lower Jurassic age associated with shale, sandstone, schist, argillite, and greenstone. South of the basin andesitic porphyry, micaceous schist, and granitic rocks, all of unknown age.	
Quaternary.	Pleistocene and Recent.	Valley fill and contemporaneous basalt near Diamond.	0–270+	Alluvium, lake and playa deposits, and eolian sediments derived from volcanic rocks of the upland; clean sand and gravel near the mouths of the principal canyons, grade laterally and feather fingerwise into silt and "clay" at the center of the basin. At least one thin layer of volcanic ash is intercalated from 3 to 6 feet below the land surface. A layer of peat as much as 30 inches thick covers most of Malheur Lake. Mantles about 900 square miles of central district. The basalt near Diamond, which is mapped separately, was extended after most of the valley filling had taken place and is either latest Pleistocene or Recent.	Pervious beds are the members, lentils, and tongues of gravel and sand which finger between impermeable beds of silt and "clay." Shallow permeable beds hold unconfined water, which is highly concentrated in dissolved salts toward the center of the basin. Deep permeable beds hold confined water and are most practicable source of ground water for irrigation; safe yield limited by transmission capacity and by feasible pumping lift. The valley fill yields flowing wells locally near Hines and in the Warm Spring Valley.
	Pleistocene.	Basalt and basaltic ejectamenta near Voltage and near Hines.	750±	Extrusives with compact, scoriaceous, and fragmental facies forming lava domes and marginal lava fields; lapilli, cinders, and bombs in and about satellitic cones.	Scoriaceous and fragmental facies are pervious; the Voltage lava field supplies one moderately large perennial spring and several flowing wells along south margin of Malheur Lake.
		Terrace deposits.	0–20	Gravel that caps small terrace remnants along margin of central alluvial plain near Burns; calcareous spring sinter along lower Prater Creek and about 2 miles southeast of Windy Point.	Above regional ground-water level.
Tertiary (?).	Pliocene (?).	Harney formation	0–750±	Massive basaltic tuff and breccia, sandstone and siltstone, some incoherent gravel; scoriaceous and massive basalt intercalated at a few horizons. Basalt member caps extensive plain of intermediate altitude in west-central part of area; outliers of formation along all margins of central area except the northern. Rests unconformably on Danforth formation.	Incoherent gravel members would transmit water readily if in the zone of saturation; inferred to be water-bearing beneath much of the central alluvial plain but not distinguishable from other bedrock units.
		Fanglomerate near Coffeepot Creek.	0–163	Semiconsolidated siltstone, sandstone, and fanglomerate; covers several square miles in north-central part of area but not discriminated elsewhere; stratigraphic horizon uncertain. May be younger than Harney formation.	Above regional ground-water level. Rests with unconformity (?) on Danforth formation.

Table 1. Generalized stratigraphy of the Harney basin. (From Piper and others, 1939)

WATER RESOURCES

Precipitation

The Harney Basin lies in a semiarid region, receiving the majority of its precipitation in the winter and spring. The average precipitation recorded for the Burns area over 48 years amounted to about 11 inches (28 m) per year, decreasing to the east and south where it averages approximately 10 inches (25 m) in the lower valley. Precipitation recorded over a recent 15 year period at Malheur Lake averaged 8.97 inches (23 m) per year (Hubbard, 1975). As would be expected, precipitation in the neighboring highlands becomes progressively greater with altitude. Leonard (1970) reports precipitation to average as much as 30 inches (76 m) per year in the northernmost part of the Silvies River basin and 19 inches (48 m) in the same basin above a gaging station in Section 30, T. 21 S., R. 30 E.

Surface Water

The greater part of the Harney basin surface water is drained by two perennial rivers and their tributaries, the southward flowing Silvies River system and the northward trending Donner und Blitzen River system, located in the north-central and south-central parts of the basin, respectively (Fig. 1). The majority of surface water is transported in the spring when most precipitation occurs and mountain snowpacks begin to melt. Much of the surface runoff either passes through or very near the geothermal units.

The Silvies River drains approximately 1,200 square miles (3,100 Km^2). It possesses a channel length of approximately 140 miles (220 Km) and the channel slope is reported to average 6 feet per mile (1m/Km), reaching a low of 2 feet per mile (.4/Km) from Burns to Malheur Lakes (Hubbard, 1975). Tributaries entering the river include the Emigrant, Sawtooth, Yellowjacket, Hay, Myrtle, Trout, Bridge, Camp, and Scatty Creeks. Near Burns, the river bifurcates into the East and West Forks, both of which connect to the Malheur Lake. Records taken over 60 years at a gaging station near Burns reveal an average flow of 118,000 acre-feet (150 hm^3) per year, approximately 89 percent occurring in the months of February through June and only 2.5 percent during July through September.

The Donner und Blitzen River has a drainage channel of about 70 miles (110 Km) and drains an area of approximately 750 square miles (2,000 Km^3), most of which is the northwest facing dip slope of Steens Mountain. Tributaries entering the river include Little Blitzen River and South Fork, Indian, Fish, Mud, Bridge, Krumbo, McCoy, Gucamonge, and Keiger Creeks. The channel slope is as high as 100 feet per mile (20m/Km) on Steens Mountain and is as low as 2 feet per mile (.4m/Km) near Malheur Lake (Hubbard, 1975). Discharge flow data obtained over 43 years at the Frenchglen gaging station (upstream from many of the tributaries) averages 86,000 acre-feet (106 hm^3) per year.

Surface water also moves toward the central lowlands via eastward flowing Silver, Big Stick, and Warm Springs Creeks located in Warm Springs Valley in the western part of the basin, and from southward flowing Poison, Prater Soldier, Rattlesnake, Cow, and Crowcamp Creeks, which drain the highland immediately to north of the Harney Valley, perenially discharging a considerable amount of water into Nine Mile and Malheur Sloughs. All discharge from the Warm Springs Valley was considered nominal by Piper and others (1939) who cite the Silver Creek as being the only channel of any consequence, draining about 900 square miles (2,300 Km^2). In the 1971, 1972, and 1973 water years, the Silver Creek discharged 10,590 acre-feet (13 hm^3), 42,590 acre-feet (52 hm^3), and 39,870 acre-feet (49 hm^3), respectively, as measured at a gaging station near Riley. What little water does drain into the Big Stick Creek comes from a 700 square mile (1,800 Km^2) area (Whistler and Lewis, 1976). Warm Spring Creek does not drain much of an area, receiving its water from perennial springs.

The ultimate destination of surface water flow is the playa lakes in the central part of the Harney basin where it is dissipated through evaporation or transpiration. The only principal surface contributors, the Silvies and Donner und Blitzen Rivers, empty into the Malheur Lake which is perched above the water table. Depending on the amount of run-off, water may eventually flow westward into Harney Lake, after filling and over spilling the banks of the Mud and Malheur Lake which rest a few feet higher in elevation.

Much of the surface water discharged into the Harney basin is used for irrigation and does not reach the playa lake area. For example, most of the water previously sited as discharge from the Silvies and Donner und Blitzen Rivers does not reach Malheur Lake. Irrigation practices on 122,700 acres (49,700 hectares) in the Silvies River basin and 39,600 acres (16,000 hectares) in the Donner und Blitzen River basin (U.S. Dept. of Agriculture, 1967) have severely curtailed the natural flow and use of these river waters, and in many years of low snowpack, the Silvies River does not contribute water to the lake at all. Measurements taken to specifically determine the source and amount of water entering the lake were conducted in 1972 and 1973 (Hubbard, 1975). This study estimated that the Silvies River contributed 28 percent [55,000 acre-feet (68 hm^3)] inflow into Malheur Lake in the 1972 water year and only about 1 percent [1,000 acre-feet (1 hm^3)] in the 1973 water year. The same study proved that the Donner und Blitzen Rivers to be the principle contributor, releasing 58 percent [110,000 acre-feet (140 hm^3)] of the total inflow in the 1972 water year and 62 percent [46,000 acre-feet (56 hm^3)] in 1973 water year. In 1973, the Donner and Blitzen water input into the Malheur Lake amounted to 98 percent of all surface flow.

Additional inflow into Malheur Lake is also received by precipitation and the Sodhouse Spring located in Sec. 35, T. 26 S., R. 32 E. Precipitation provided 14 percent [27,000 acre-feet (33 hm^3)] of the lake water in the 1972 water year and 28 percent [19,000 acre-feet (23 hm^3)] in the 1973

water year (Hubbard, 1975). Measurements in the 1972 and 1973 water years showed the Sodhouse Spring accounted for 5 percent [8,000 acre-feet (10 hm^3)] and 12 percent [9,000 acre-feet (11 hm^3)] of the lake water in those respective periods (Hubbard, 1975).

The water depths of Malheur, Mud and Harney Lakes are extremely shallow. These depths probably do not amount to much more than a few tens of feet for Harney Lake and 5 feet (1.5 m) for Malheur Lake. Therefore, the interplay between inflow and evaporation largely determines area extents of the lakes (Fig. 2) and whether they form a contiguous water body. Piper and others (1930) reported that since 1895, the total surface area of the lakes had ranged from 2 to 125 square miles (5 to 324 Km^2) and that a surface elevation of 4,091.5 feet (1,247 m) must be reached in Malheur Lake before water would enter Mud and possibly Harney Lakes. Hubbard (1975) noted a variance in surface area of Malheur Lake of 15,000 to 62,000 acres (6,000 to 25,000 hectares) between March 1, 1972 and September 30, 1973.

Ground Water

The source of ground water, precipitation, enters the Harney Basin via infiltration, percolation of mountainous stream flow through highly permeable rocks, and stream losses near the edge of the valley, particularly the apex of the Silvies alluvial fans which constitutes a major source for underground water recharge (see Piper and others, 1939). After penetrating the surface, the water either enters a confined or unconfined reservoir, and like the surface waters, moves toward the low-central playa lake area. Except for contribution from the Sodhouse Spring, ground water inflow into Malheur lake appears to be negligible (Hubbard, 1975).

The unconfined reservoirs are shallow and belong to the sand and gravel valley fill. The talus deposits from the adjacent uplands and alluvial fans, particularly the Silvies fan, serve as excellent unconfined aquifers. Toward the lower, central parts of the valley, the effect of overlying peat beds, increased clay and fines content, and a decrease in large rock fragments results in unconfined poor aquifers. Confined reservoirs are generally deeper, consisting of alluvium and Tertiary volcanic and sedimentary rocks, and may be perched and/or artesian in nature. The productability of these reservoirs varies over the basin (see General Geology).

The water table in the Harney Basin will fluctuate seasonally and in places may be perched. From data presented by Robison (1968), average depth of water table may vary as much as 100 feet (30 m) in the north central part of the basin, 200 feet (60 m) south and southwest of Harney Lake, and 300 feet (90 m) at the dip slope of Steens Mountain. These averages include the shallow water table depth in the valley areas and the deeper depths necessary to reach water in the neighboring highlands. Measurements of many observation wells in the valley bottom show a depth to water table

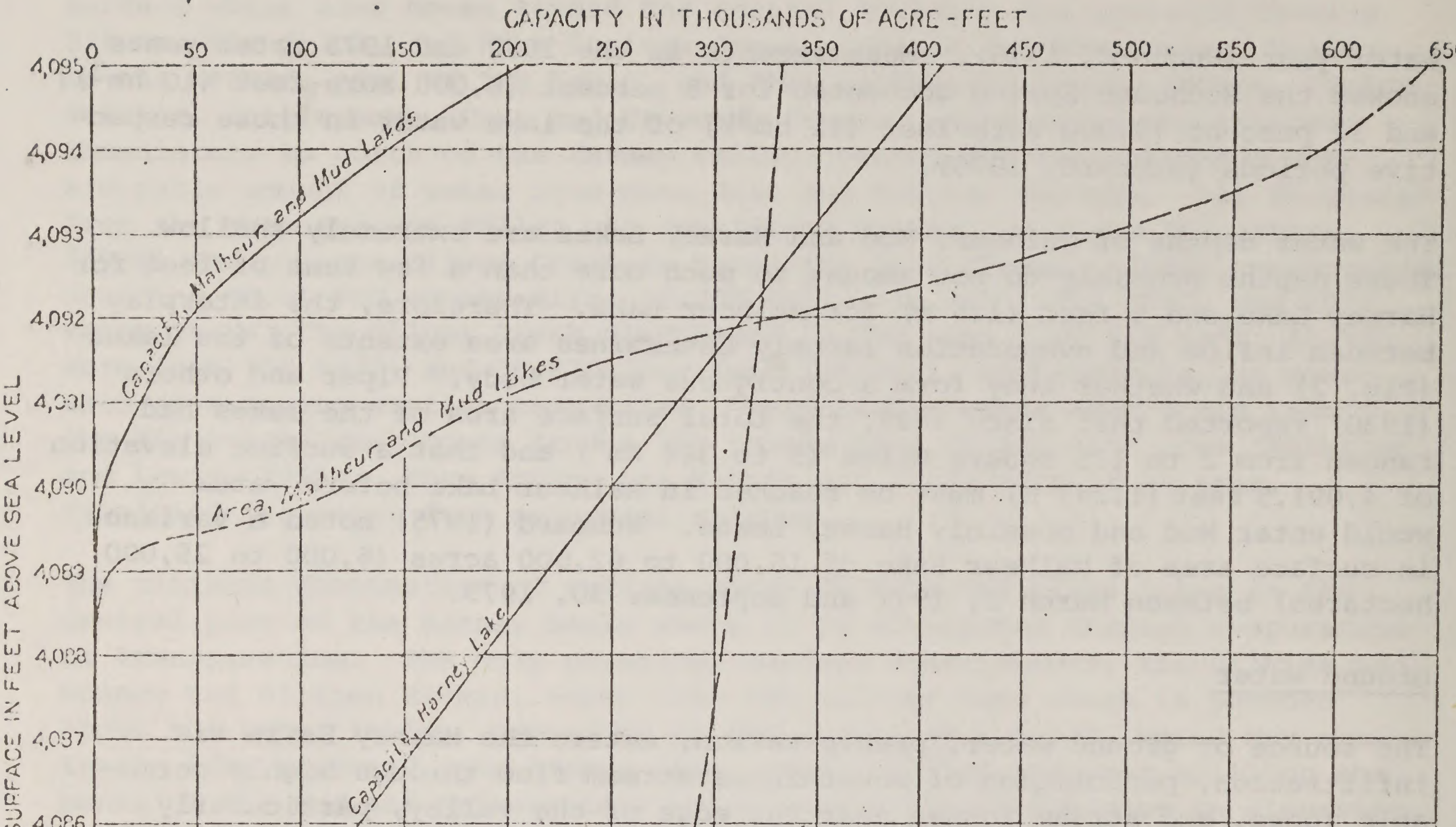


Figure 2. Area and capacity curves for Malheur, Mud, and Harney Lakes. (From Piper and others, 1939)

of near surface to more than 50 feet (15 m) (Leonard, 1970). Figures 3 and 4 show that wells observed by the State Engineer give similar depths. Confined and unconfined water table contours drawn by Leonard (1970) and Piper and others (1939), respectively, are concaved south and show a gradual decline toward Malheur Lake from the west, north, and east margins of the valley. In the unconfined valley fill, the water table declines more steeply than the surface toward Malheur Lake (Piper and others, 1939).

Confined water in the Harney Basin may be under abnormal pressure so that the piezometric surface of the static level may be above or below that of the unconfined water surface. In many cases, the pressure is sufficient enough that water within the aquifer flows at the surface through wells and springs. Although geologic structure is felt to favor flowing wells over most of the valley (Leonard, 1970), sustained artesian flows appear to be unique to the valley-highland margin. In 1930 and 1931, Piper and others (1939) showed that in some parts of the valley aquifers were actually under pressured and consist of piezometric surfaces lower than that of the shallow, unconfined water table.

Ground water recharge for a 210 square mile (544 Km^2) area near the Silvies River and the western part of the valley was estimated to be about 40,000 acre-feet (49 hm^3) per year by Piper and others (1939). Leonard (1970) estimates a total recharge of approximately 60,000 acre-feet (74 hm^3) per year for the north-central valley area, including about 22,000 acre-feet (27 hm^3) which moves into the Tertiary volcanics and sediments. Robison (1968) suggests a natural recharge for the entire Harney Basin of roughly 170,000 acre-feet (209 hm^3) per year.

Ground water storage in the Harney Basin has been roughly estimated at 39 million acre-feet (47,970 hm^3) (Robison, 1968). Of this amount, 15 million acre-feet (18,500 hm^3) lie above 500 feet (150 m) and 24 million acre feet (29,500 hm^3), calculated from unadequate data, lies below 500 feet (150 m) and is potentially recoverable (Robison, 1968). Leonard (1970 reports that a 100-foot (30 m) thick valley fill zone in a 56 square mile (145 Km^2) area of the Silvies alluvial fan contains about 400,000 acre-feet (490 hm^3) of water. Potential additional storage capacity is estimated at 1.7 million acre-feet (2,100 hm^3) (Robison, 1968).

The majority of ground water has been removed from the Harney Valley area where need is greatest. Wells have yielded from about 100 to 1,000 gpm (380 to 3,800 lpm) in the valley and, in many areas, average several hundred gallons per minute (Leonard, 1970). Data on many of these wells is shown in Appendix I and II, but it should be kept in mind that data from Appendix I is old and much of the information may not be reliable. Leonard (1970) reports that the heads in the valley since 1930-31 have declined so that some wells no longer flow and others have diminished in flow.

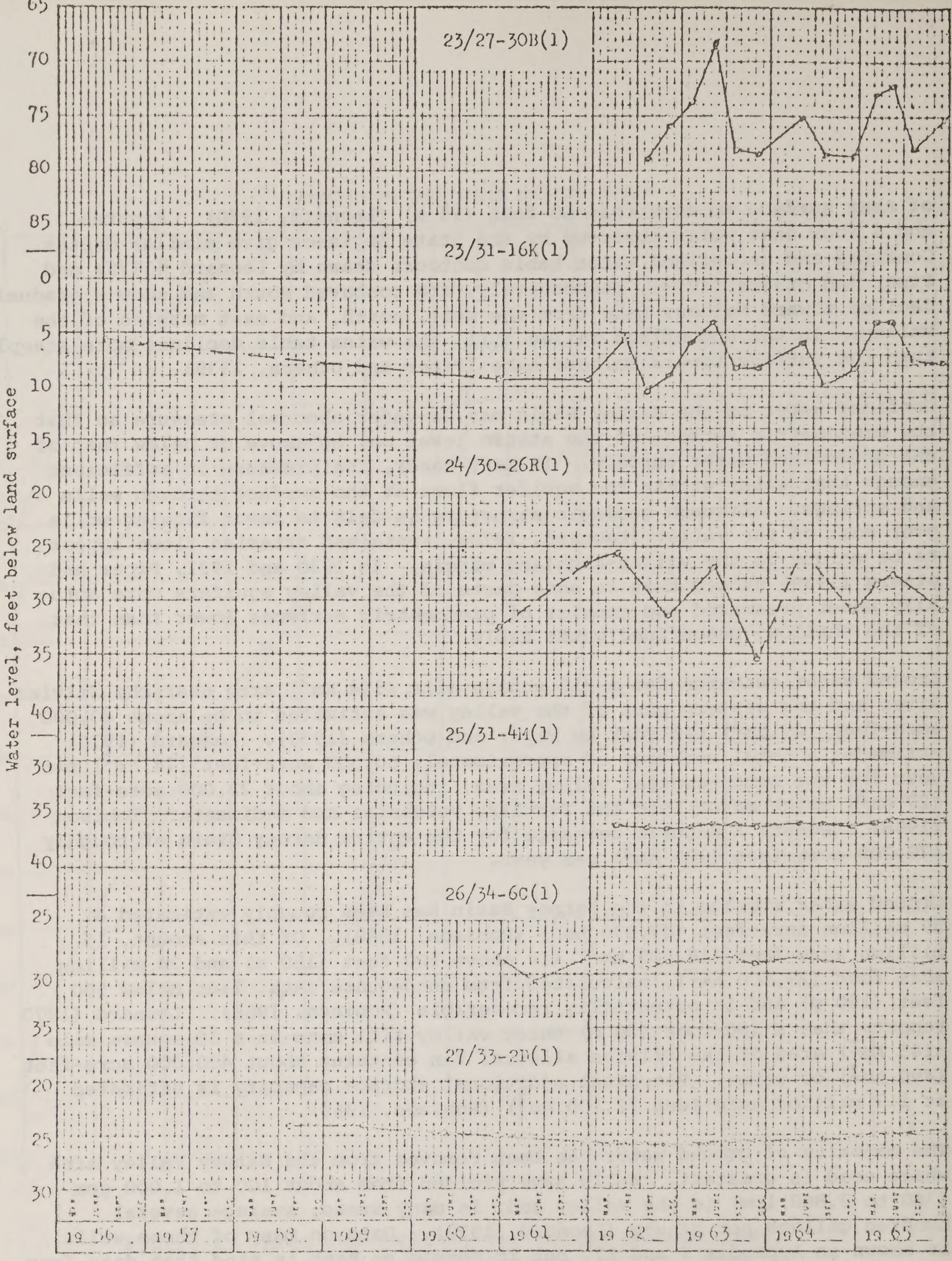


Figure 3. Depths to water table from observed wells in the Harney basin, 1956-65. (From Sceva and Debow, 1966)

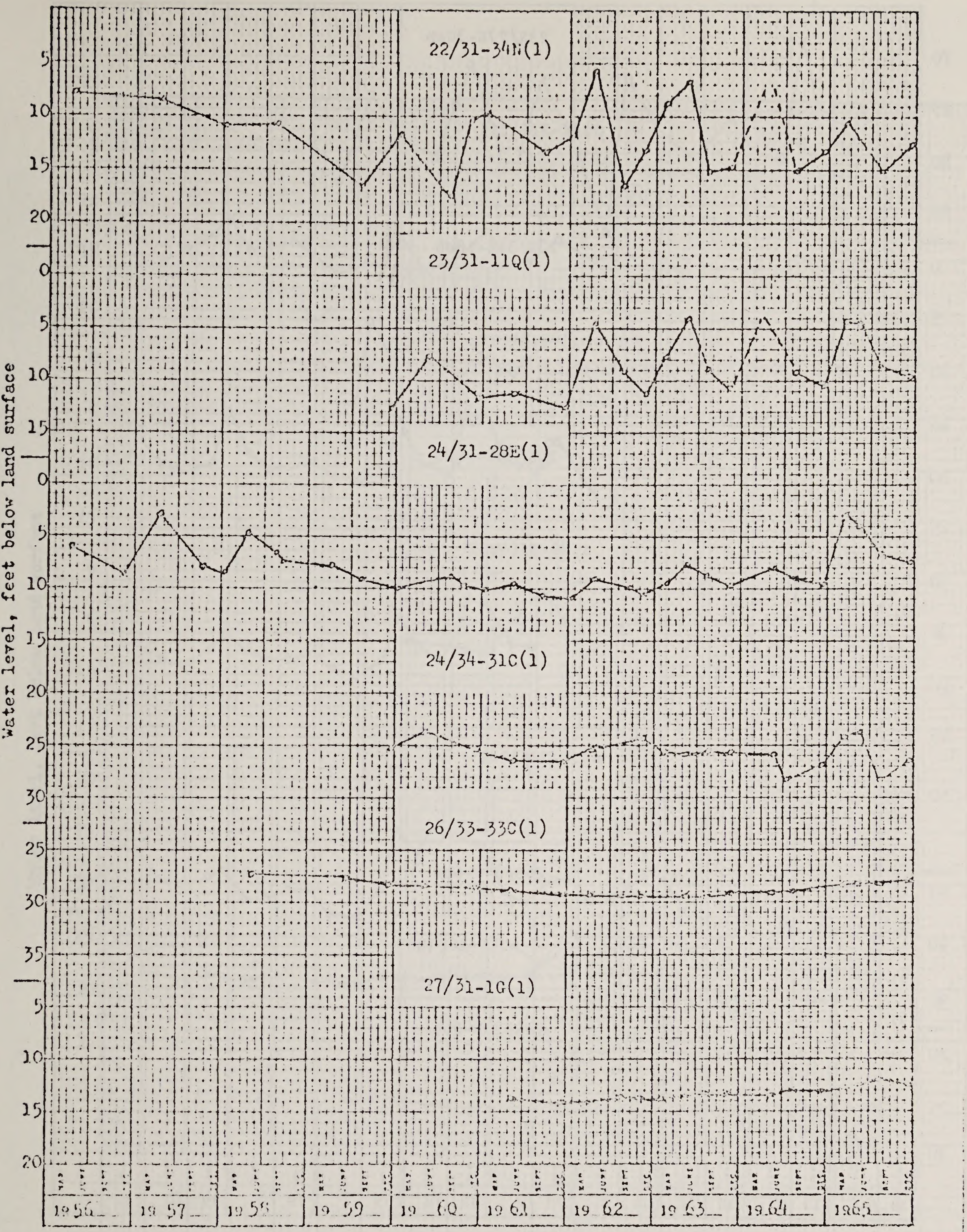


Figure 3. Depths to water table, 1956-65(continued).

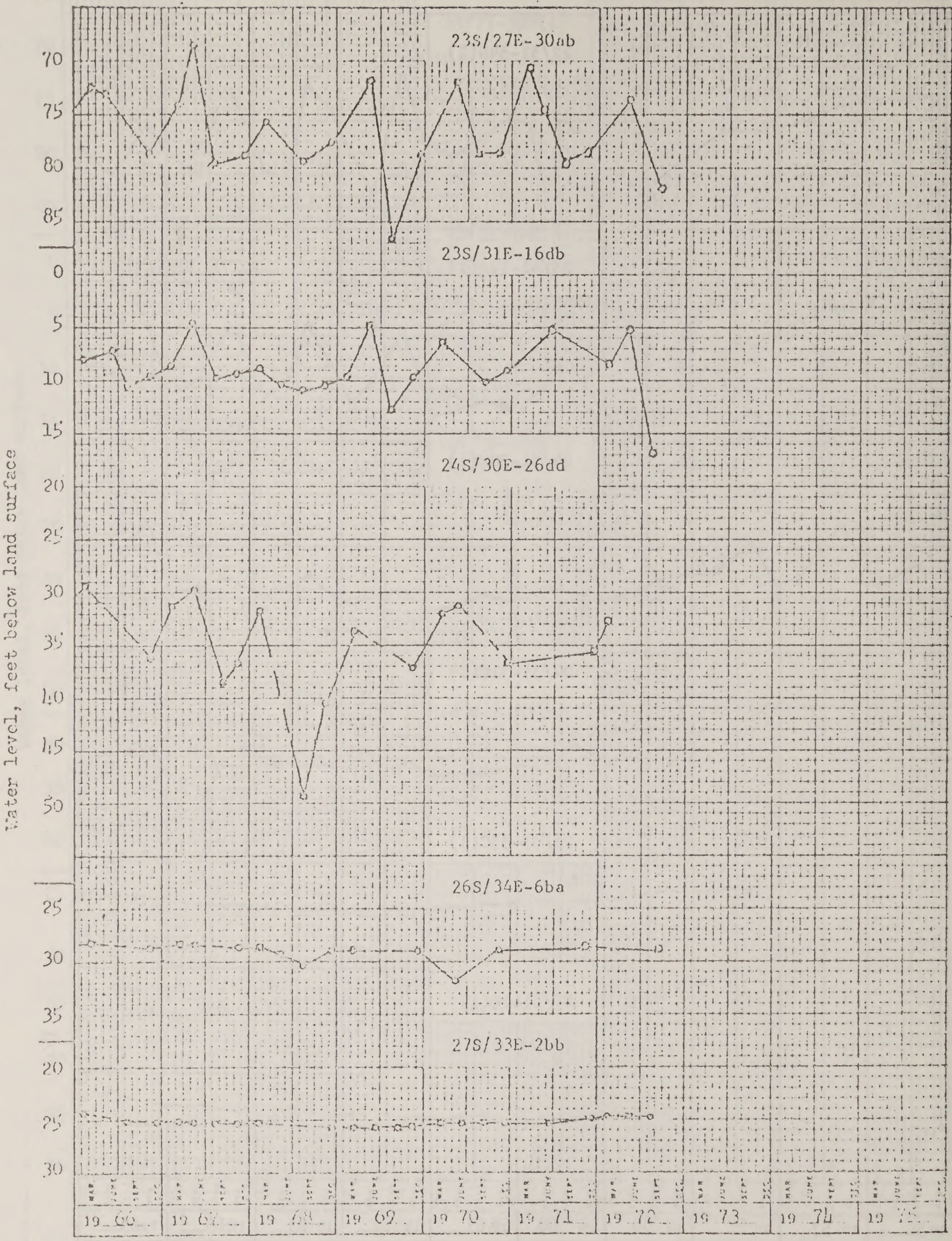


Figure 4. Depths to water table from observed wells in the Harney basin, 1966-72. (From Bartholomew and others, 1973)

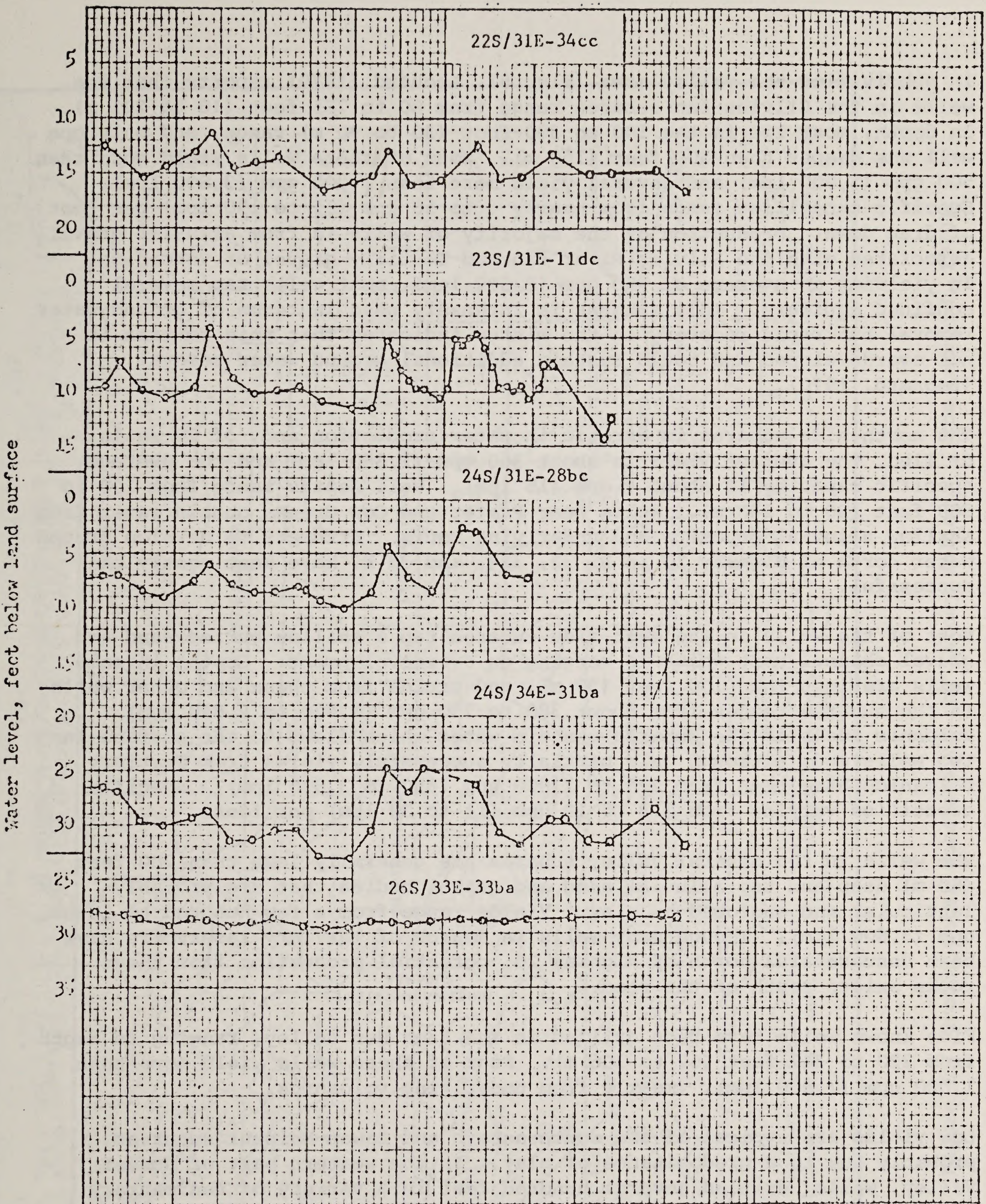


Figure 4. Depths to water table, 1966-72 (continued).

In subdividing the valley area (Fig. 5), Leonard (1970) reports that the wells in the Silvies-fan subarea range from 60 to 725 feet (18 to 221 m) in depth, most lie in the 100 to 300-foot (30 to 90 m) range, and only one well was deeper than 500 feet (150 m). Most of these wells yield more than 500 gpm (1,900 lpm) and several yield more than 1,000 gpm (3,800 lpm). Specific capacities range from nearly 3 to 50 gpm (11 to 190 lpm) per foot of draw down. Production of the majority of wells is from alluvial gravel associated with the Silvies River fan and Tertiary gravel or volcanics. In yielding an average of 700 gpm (2,600 lpm), most wells tap several confined aquifers. This subarea is intensely used in terms of ground water removal but rapid recovery in the winter indicates that this subarea is not overdeveloped and could sustain additional ground water removal (Leonard, 1970).

The north-side subarea is erratic in water production and, of 20 wells drilled, the average yield is about 360 gpm (1,360 lpm) and the average specific capacity is about 4 gpm (15 lpm). Well depths range from 100 to 800 feet (30 to 240 m). Wells near Prater and Cow Creeks obtain water from shallow alluvial deposits and underlying rocks. Attempts to develop ground water north of Highway 20 in R. 32, 32½, and 33 E. have been mostly unsuccessful.

Most of the wells in the east-side subarea tap a shallow buried sand and gravel channel unit which is verging on overdevelopment. Depths in some wells are less than 100 feet (30 m), and yields from these and other wells in the subarea ranges from about 380 to 750 gpm (1,440 to 2,840 lpm). Volcanic rocks in the subarea contain water which flows to the surface in two wells and, although only partially successful, yields from Tertiary volcanics have been from 225 to 1,000 gpm (850 to 3,800 lpm), specific capacities varying from 2.8 to 10 gpm (11 to 38 lpm) per foot.

The wells in the central valley subarea are generally less than 200 feet (60 m) deep and tap alluvial sand and gravel bodies that are probably lenticular and enclosed by clay. Yields range from a few hundred to 1,000 gpm (3,800 lpm). Though many wells in search of Tertiary reservoirs have been unsuccessful north of Highway 20, potential production from these rocks exists south of the road.

Five known wells have been drilled in the Sage Hen valley, ranging in depth from 220 to 347 feet (67 to 106 m). Four of these wells yield more than 1,000 gpm (3,800 lpm), mostly from underlying volcanics.

Low yields are typical of the southeastern and Lawen-Malheur subareas, probably due to a predominance of clay. In the western part of Sunset Valley, wells drilled several hundred feet in a variety of sedimentary and volcanic rocks have yielded as much as 100 to 300 gpm (380 to 1,140 lpm). Recharge potential is considered limited in Sunset Valley and probably could not undergo large ground water withdrawals (Leonard, 1970).

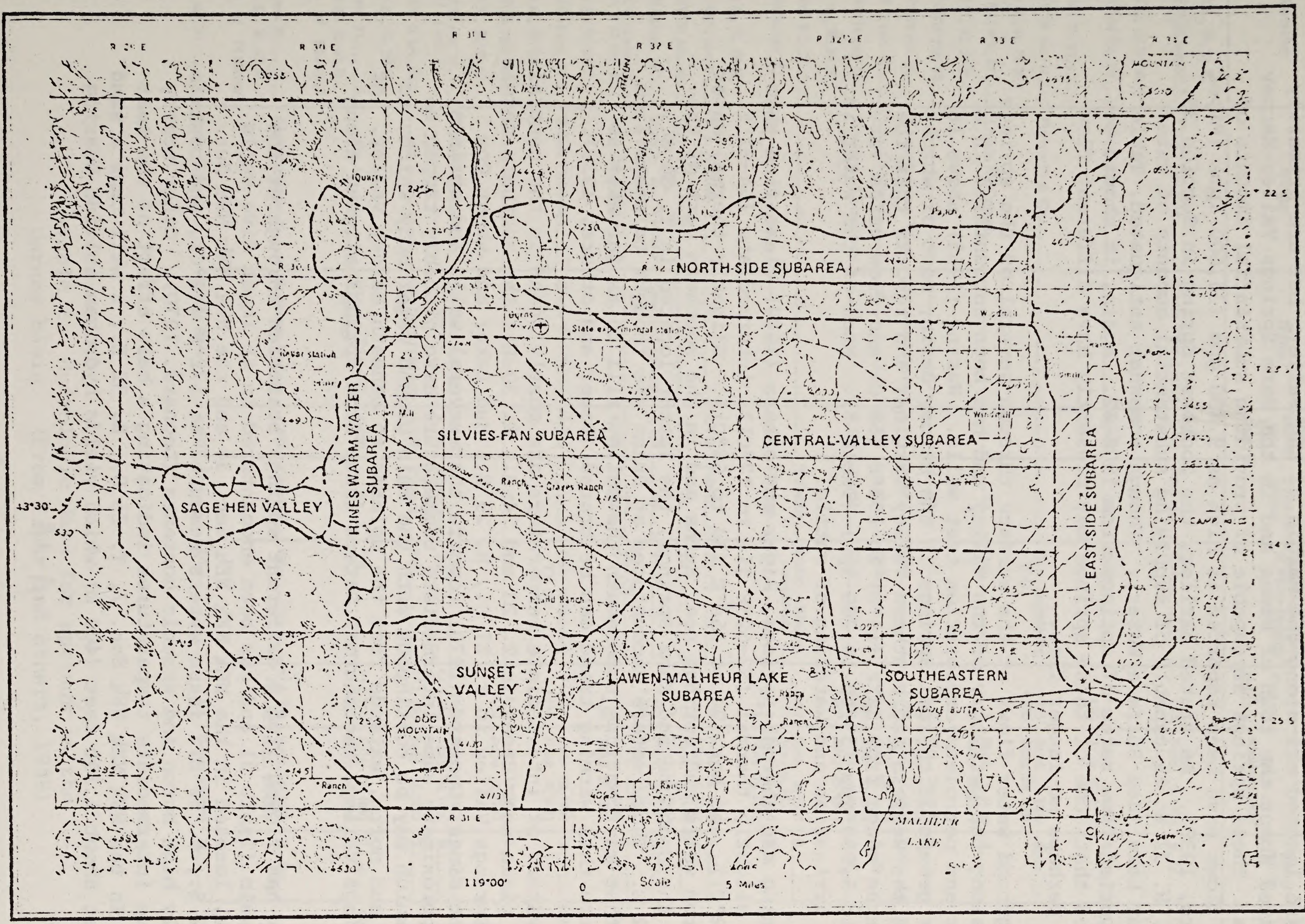


Figure 5. Ground water subareas of the Harney Valley. (From Leonard, 1970)

Springs are located all along the margin of the valley, but are primarily concentrated about the town of Hines and in the Warm Springs Valley-Harney Lake area. These springs arecapable of providing substantial amounts of water as flows have been reported as high as 9,400 gpm (35,600 lpm) (Piper and others, 1939). As stated earlier, the Sodhouse Spring in Section 35, T. 26 S., R. 32 E. is capable of supplying substantial amounts of water to Malheur Lake (see Surface Water). Though somewhat antiquated, Table 2 shows reported flow rates of springs from 1902-32. Again, it should be remembered that some of these springs may presently have different flow rates or perhaps no longer flow.

Thermal ground water flows at the surface through several of the springs located along the periphery of the valley and has been encountered in a few water and petroleum exploration test wells. Waring (1965) shows 18 single or groups of thermal springs in the Harney Basin, most of which lie along the western and southern valley margins, and reports that the temperatures range from 52°F (11°C) to 154°F (68°C) and flow rates vary from 10 to 5,200 gpm (39 to 19,700 lpm) (Table 3). Much of the water is used for irrigation and watering of cattle.

In examining the thermal springs, Piper and others (1939) classified them as being slightly thermal (52-62°F [11 to 17°C)], intermediate [64-82°F (17 to 22°C)], and hot [94 to 154°F (34 to 68°C)]. Slightly thermal water issues from wells and springs near Burns and in the southern part of the basin at the Sodhouse and Knox Springs, the latter located in T. 31 S., R. 32-1/2 E. Those waters encountered at Burns are thought to issue from a fault that may continue underneath the valley fill to as far east as Crane where this warming trend can be traced (Piper and others, 1939).

Thermal waters of intermediate temperature are mostly found in the central alluvial plain near Hines in T. 23 and 24 S., R. 30 E.; the southern margin of Warm Springs Valley in T. 27 S., R. 29 E.; Mud Lake; and about Cow Creek. At Hines, Leonard (1970) reports that several wells and springs of the approximate same intermediate temperature have probably tapped an aquifer which may be continuous with the main ground water body which, to the east and north, extends from the uplands to beneath Harney Valley. At Warm Springs Valley, the thermal waters issue from springs aligned along a fault.

Hot water has flowed from 8 different springs scattered throughout the Harney Basin (Table 3) and has been encountered in at least five wells. Two wells, located in the NE¼ NE¼ NE¼ Sec. 34 and the NW¼ NW¼ NW¼ Sec. 35, T. 22 S., R. 32 E., issue waters measured at 172°F (72°C), and contain abnormally high boron and arsenic contents (Leonard, 1970). Other nearby wells have intermediate temperatures indicating a halo effect of the heat source. In the NW¼ NE¼ NW¼ Sec. 7, T. 25 S., R. 32 E., a well taps a sand aquifer at about 1,300 feet (400 m) which yields hydrogen sulfide bearing

[Use of water: B, bath; Ind., industrial; Ir., irrigation; S, stock]

Location	Owner	Name	Altitude above sea level (feet)	Type of spring	Geologic horizon of water-bearing bed [1]	Discharge: Gallons a minute	Discharge: Date of measurement	Use of water	Temperature (° F.)	Remarks
T. 22 S., R. 31 E.										
NW¼SW¼ sec. 27	Frank Whiting	Uncle Tom Spring	4,165	Seepage	Qal	[2] 75 [2] 125	Sept. 6, 1930 May 27, 1931	S, Ir.		Irrigates meadow; noticeable annual fluctuation.
T. 22 S., R. 32 E.										
SW¼NE¼ sec. 26	—— Houser		4,165	do	Qal	[2] 20 [2] 65	Sept. 1, 1930 May 28, 1931	S		Reported not to have gone dry in 45 years.
T. 22 S., R. 32½ E.										
NE¼SW¼ sec. 14	Danforth & Co.				Qal (overlying Td).	[4] 225 [2] 225	Sept. 6, 1930 May 28, 1931	S, Ir.	72	Aids in irrigation of 60-acre meadow.
T. 22 S., R. 33 E.										
SE¼NE¼ sec. 20	Archie McGowan			do	Qal	2 2	Sept. 8, 1930 May 28, 1931	S	52	
T. 23 S., R. 30 E.										
NW¼NE¼ sec. 22				do	Qal	[2] 10 [2] 5	Oct. 21, 1930 May 29, 1931	S	50	
NE¼NE¼ sec. 35	Edward Hines Western Pine Co.	Mill Pond Spring	4,135	Joint	Qbh	[2] 500 [2] 500	Sept. 4, 1930 May 29, 1931	Ind.	73–80	Supplies sawmill log pond.
SE¼SE¼ sec. 35	Mrs. Goodman		4,138	do	Qbh	[2] 300 [2] 300	Sept. 3, 1930 May 29, 1931	S., Ir.		Aids in irrigation of meadow.
NW¼SW¼ sec. 36	Western Compensation Co.		4,138	do	Qbh	[2] 300 [2] 300	Sept. 3, 1930 May 29, 1931	S, Ir.	78	Do.
T. 23 S., R. 34 E.										
Lot 2, sec. 6				Tubular	Older siliceous extrusives.	[2] 10 [2] 10	Sept. 8, 1930 May 28, 1931	S	62	
NE¼SW¼ sec. 7			4,154	Seepage	Qal	[2] 5 [2] 5	Sept. 8, 1930 May 28, 1931	S	54	
T. 24 S., R. 30 E.										
SW¼NW¼ sec. 9	T. J. Jenkins		4,140	Joint	Td (?)	[4] 330 [4] 250	Sept. 3, 1930 May 29, 1931	S., Ir.	54	Irrigates 40-acre meadow.
NW¼SW¼ sec. 10	Vermont Loan & Trust Co.			do	Td (?)	[2] 75 [2] 5	Sept. 3, 1930 May 29, 1931	S	64	
SE¼SW¼ sec. 11	Oregon & Western Colonization Co.	Roadland Spring	4,135	do	Td	[4] 495 [4] 370	Sept. 3, 1930 May 29, 1931	S., Ir.	72	Irrigates meadow.
NE¼NW¼ sec. 15				do	Qal (?)	[2] 1	Aug. 12, 1931	S	56	
NW¼NW¼ sec. 24	Mrs. Doug Baker		4,128	Seepage	Th (?)	[2] 50 [2] 50	Sept. 4, 1930 May 29, 1931	S	62-70	Group of 5 orifices.
T. 24 S., R. 33 E.										
NW¼SE¼ sec. 31	Ralph Catterson	Crane Hot Spring	4,125		Qal (overlying Th (?).	[4] 180 [4] 180	Oct. 10, 1930 June 3, 1931	B	122-126	Water pumped to natatorium.
T. 25 S., R. 30 E.										
SE¼SW¼ sec. 22		Weaver Spring		do	Th	[2] 20 [2] 10	Oct. 16, 1930 June 2, 1931	S	53	
T. 26 S., R. 28 E.										
SE¼SE¼ sec. 26	William Hanley Co.	OO Cold Spring	4,120		Th	[2] 450±	July 22, 1931	S., Ir.	58	
NE¼SE¼ sec. 31	do	OO Spring	4,120	Fissure or joint.	Td	[4] 5,350	May 30, 1932	S	71	
NE¼NW¼ sec. 36	do	OO Barnyard Spring.	4,120	Fissure	Td	[4] 1,750	July 21, 1931	S	72	
T. 26 S., R. 29 E.										
Lot 4, sec. 31	do	Basque (East OO) Spring.	4,120	do	Td	[4] 1,200 [4] 900	July 22, 1931 May 30, 1932	S., Ir.	68-74	
T. 26 S., R. 31 E. "South of Malheur Lake"										
Lot 6, sec. 35	Alva Springer	Sodhouse Spring	4,093	Gravity	Qbv	[4] 5,200 [4] 4,100	Sept. 9, 1930 Aug. 22, 1931	S., Ir.	54	
T. 26 S., R. 32 E. "South of Malheur Lake"										
Lot 11 sec. 31	T. T. Dunn	Indian Spring	4,093	Seepage	Qbv	[2] 5±	Sept. 10, 1930	S	58	

Table 2. Hydrologic data for springs in the Harney basin. (From Piper and others, 1939)

A-19

T. 27 S., R. 29 E.										
SW¼NW¼ sec. 5	Lewis M. Hughet	Johnson Spring	4,115	Fissure	Td	[3] 850	July 24, 1931	S, Ir	68-72	
NE¼NE¼ sec. 8		Hughet Spring	4,105	do	Td	[4] 5,850	do	S, Ir	68	Irrigates 500-acre meadow.
						[4] 5,400	May 30, 1932			
SE¼SE¼ sec. 9	Edith Sizemore	Sizemore Upper Spring.	4,120	do	Td	[4] 1,160	July 28, 1931	S, Ir	67	
NW¼NW¼ sec. 15	do	Sizemore Lower Spring.	4,120	do	Td	[4] 410	July 28, 1931	S, Ir	66	
NE¼SE¼ sec. 15	A. W. Hulburt	Sizemore Upper Spring.	4,105	Seepage	Qal	[3] 25±	July 28, 1931	S		
T. 27 S., R. 29½ E.										
(7)	Edith Sizemore	Sizemore Lower Spring.	4,082	Concealed fissure.	Qal (overlying Td?).			None	68-70	Group of springs.
(7)			4,082	do	do			do	104	Group of springs within area of ¼ square mile.
(7)			4,082	do	do			do	92	Group of springs.
(7)			4,085	do	do	[3] 20	Aug. 21, 1931	do	108	
NE¼SE¼ sec. 36				do	Td	[5] 150	Sept. 11, 1930	S	140-154	Red algae on water.
						[5] 150	June 2, 1931			
T. 27 S., R. 30 E.										
Lot 11 sec. 4	W. J. Dunn		4,096	do	Qal (overlying Td).	[3] 25	June 4, 1931	S	70	
SE¼NW¼ sec. 4	do		4,095	do	do	[3] 10	do	S		
(7)			4,098	do	do	[5] 5	June 17, 1931	S	66	
Lot 5 sec. 8		Lynch Spring	4,095	do	do	[3] 25	June 4, 1931	S	65½	
T. 28 S., R. 29 E.										
SW¼NE¼ sec. 20		Buzzard Spring	4,450±		Td		Sept. , 1932	S		
T. 31 S., R. 32 E.										
NW¼NE¼ sec. 13	Eastern Oregon Livestock Co.	Hog House Spring		Fissure	Ts	[3] 900	Aug. 27, 1932	Ir	78-80	
T. 31 S., R. 32½ E.										
NW¼SE¼ sec. 21	do	Knox Spring			Ts	[3] 450	July , 1932	Ir		
T. 32 S., R. 32 E.										
SW¼NE¼ sec. 12	do			Fissure	Ts	[3] 500	Aug. 27, 1932	Ir	88-89	
T. 32 S., R. 32½ E.										
NE¼SW¼ (?) sec. 5	do				Qal (overlying Ts).	[3] 100	do	S	83	

[1] Qal, valley fill and alluvium; Qb, late basalt (Qbb, near Hines; Qbv, near Voltage); Th, Harney formation; Td, Danforth formation; Ts, Steens basalt.
[3] Estimated.
[4] Current-meter measurement.
[5] Float measurement.
[7] Unsurveyed land within inner meander line of Harney Lake.

Table 2. Hydrologic data for springs in the Harney basin (continued).

No. on figure	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	Remarks and additional references
51A	Sec. 14, T. 22 S., R. 32½ E., 17 miles northeast of Burns.	72	225	Alluvium	Water contains 72 ppm of dissolved solids. Used for irrigation; also water supply for cattle.
52	Millpond Spring and other springs in secs. 35 and 36, T. 23 S., R. 30 E.	73-80	1,200	Interbedded tuff and basalt (Quaternary).	3 springs. Water contains 121 ppm of dissolved solids. Flow maintains log pond for saw mill. Refs. 371, 491.
52A	0.75 mile south of Millpond Spring (No. 52).	78	300	do	Water used for irrigation; also water supply for cattle.
52B	Goodman Spring, 1 mile south of Millpond Spring (No. 52).	Warm	300	do	Do.
52C	3.5 miles southwest of Millpond Spring (No. 52).	64	75	Lake beds, tuff, and rhyolite.	Water supply for cattle.
52D	1.5 miles east of spring No. 52C	72	485	do	Water contains 113 ppm of dissolved solids. Used for irrigation; also water supply for cattle.
52E	Baker Spring, 1.5 miles southeast of spring No. 52D.	62-70	60	do	5 springs. Water supply for cattle.
53	Crane Hot Spring, in sec. 34, T. 24 S., R. 33 E., near Crane Creek Gap 4 miles northwest of Crane.	122-126	180	Alluvium overlying lake beds (Pliocene).	2 main springs. Water contains 427 ppm of dissolved solids. Used for bathing. Refs. 371, 487, 491.
56	Sec. 12, T. 26 S., R. 27 E., near south shore of Silver Lake.	68	45	Alluvium	Water used for irrigation. Ref. 491.
57	Sec. 33, T. 26 S., R. 28 E., 3.5 miles east of Iron Mountain.	68	10	do	Water supply for cattle. Ref. 491.
58	Double-O Spring, in sec. 34, T. 26 S., R. 28 E., 1.5 miles west of Double-O Ranch.	74	5,350	Interbedded tuff, rhyolite, and lake beds (Pliocene).	Water used for irrigation; also water supply for cattle. Refs. 141, 486, 491.
59	Double-O Barnyard Spring, in sec. 33, T. 26 S., R. 28 E., on Double-O Ranch.	72	1,750	do	Water used for irrigation; also water supply for cattle. Ref. 486.
60	Basque (East Double-O) Springs, in sec. 31, T. 26 S., R. 29 E., 1 mile southeast of Double-O Ranch.	67-74	1,800	do	Several springs. Water used for irrigation; also water supply for cattle. Ref. 491.
61	Johnson Springs, in sec. 5, T. 27 S., R. 29 E., 2.5 miles southeast of Double-O Ranch.	72	900	do	Several springs. Water used for irrigation; also water supply for cattle. Refs. 486, 491.
62	Hughet (Crane Creek) Spring, in sec. 8, T. 27 S., R. 29 E., 3 miles southeast of Double-O Ranch.	68	5,900	do	Water used for irrigation; also water supply for cattle. Refs. 141, 486, 491.
62A	Sizemore Upper Spring, in sec. 9, T. 27 S., R. 29 E., 5 miles southeast of Double-O Ranch.	67	1,160	do	Water used for irrigation; also water supply for cattle. Ref. 486.
62B	Sizemore Lower Spring, in sec. 15, T. 27 S., R. 29 E., 0.5 mile southeast of Sizemore Upper Spring (No. 62A).	66	410	do	Do.
62C	Hurlburt Spring, in sec. 15, T. 27 S., R. 29 E., 1 mile southeast of Sizemore Lower Spring (No. 62B).	Warm	25	Alluvium	Water supply for cattle. Ref. 486.
62D	Between high- and low-water boundaries of Harney Lake.	66-108	30	do	Several springs in southern and eastern parts of lake. Ref. 486.
63	Lynch Spring, in sec. 8, T. 27 S., R. 30 E.	65	25	do	Water smells of H_2S. Ref. 486.
63A	Dunn Spring, in sec. 4, T. 27 S., R. 30 E., on south side of Mud Lake.	65; 70	10; 25	do	2 springs 0.5 mile apart. Water supply for cattle. Ref. 486.
64	Sec. 36, T. 27 S., R. 29½ E., 0.5 mile from southeast shore of Harney Lake.	154	180	Lake beds, tuff, and rhyolite (Pliocene).	Refs. 371, 491.
64A	Sodhouse (Springer) Spring	54	1,800-5,200	Lake beds and playa deposits.	Water contains 226 ppm of dissolved solids. Used for irrigation; also water supply for cattle. Refs. 486, 491.
65	Hoghouse Spring, in sec. 13, T. 31 S., R. 32 E., on west side of Donner and Blitzen River valley.	78-80	1,800	Alluvium near faulted basalt (Tertiary).	Water used for irrigation. Refs. 486, 491.
66	Sec. 5, T. 32 S., R. 32½ E., 1 mile northeast of P Ranch.	83	100	do	Water supply for cattle. Refs. 486, 491.
67	Sec. 12, T. 32 S., R. 32 E., 1 mile southwest of P Ranch.	89	500	do	Water used for irrigation. Refs. 486, 491.

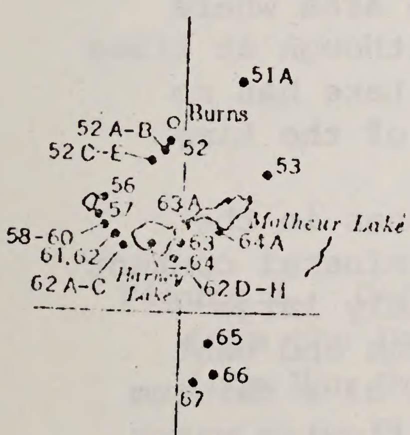


Table 3. Thermal springs of the Harney basin. (From Waring, 1965)

water at 105°F (41°C). A petroleum exploration test well drilled in the SE¼ NE¼ NW¼ Sec. 8, T. 24 S., R. 32 E. was drilled to a depth of 2,812 feet (857 m) and encountered 115°F (46°CO water at 2,000 feet (607). An earlier petroleum exploration test well drilled to 1,430 feet (436 m) in the NE¼ Sec. 5, T. 26 S., R. 32 E. encountered hot water between 1,330 and 1,402 feet (405 and 427 m) which, in 1931, flowed at 30 gpm (114 lpm). Data extracted from the Dog Mountain petroleum exploration test well in the SE¼ SE¼ Sec. 24 T. 25 S., R. 3 E. has been used to produce a geothermal gradient curve (Fig. 6).

The known hot springs occur in three areas; 1) grouped along the southern part of Harney Lake (No. 62D-Table 3); 2) three along the Donner and Blitzen River basin (No. 65, 66, 67-Table 3); 3) and one at Crane Hot Springs in the NE¼ NE¼ Sec. 34, T. 24 S., R. 33 E., (No. 53-Table 3). Discharge from the Crane Hot Springs, once used for a natatorium measured as much as 176°F (80°C) (Leonard 1970).

The source of the thermal waters are basically thought to be the result of heating meteoric waters by a magmatic source, which in most regions, is felt to be deep seated. Such has been postulated by Piper and others (1939), for the Harney basin. However, Leonard (1970) feels it is not necessary to postulate great depths in the area of Hines due to the steep geothermal gradient in the Harney Valley. In any event, the heated water, using faults as avenues of ascent, may then flow to the surface or perhaps enter an aquifer and mix with the lower temperature water. The latter is thought to be the case for anonymously high temperatures encountered in some aquifers.

WATER QUALITY

The quality of water in the Harney Valley ranges from excellent to poor (Appendix III). Surface waters are generally of excellent quality as is ground water along the valley margins where even thermal waters are of irrigation and stock watering quality (Table 3). However, quality of ground water tends to be progressively worse toward the playa lake area where the water table may be so mineralized as to be unusable, although at times it can be palatable (Appendix II). As water from Harney Lake has no release other than evapotranspiration, it is unusable most of the time.

Leonard (1970) reports water from the principal confined zones in the Harney Valley range from a calcium bicarbonate type of low mineral content to a sodium chloride and sodium bicarbonate type of moderately large mineral content (Appendix III). Ground water along the north and east side of the valley is generally low in dissolved solids, is of a calcium bicarbonate type, and suitable for most uses. Near Hines, flowing water is also low in dissolved solids, is of the sodium bicarbonate type, and is suitable for domestic and irrigation use. Although moderately mineralized

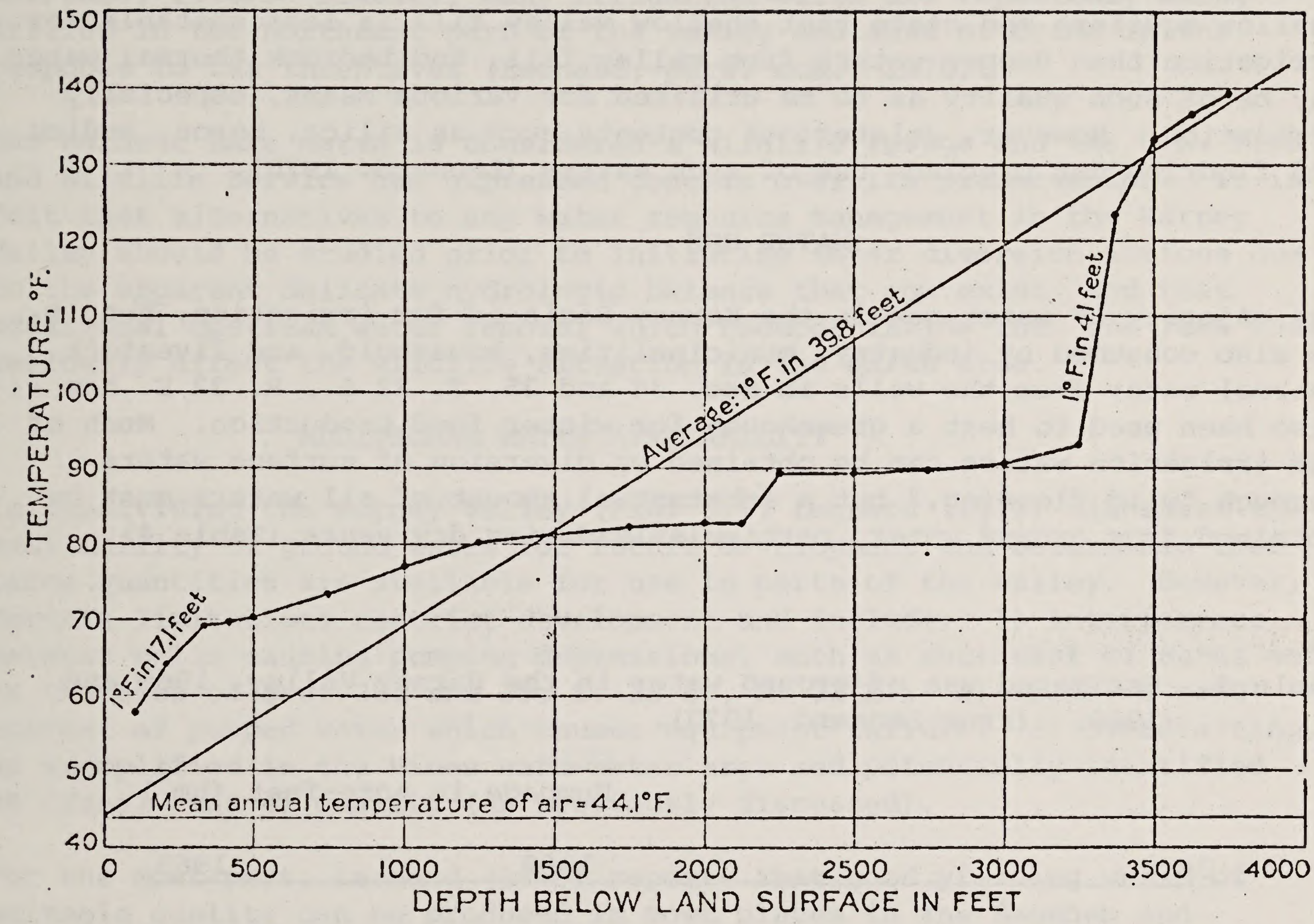


Figure 6. Geothermal gradient curves drawn from data obtained from the Dog Mountain petroleum exploration test well. (Modified from Van Orstrand, 1924 by Piper and others, 1939.)

and of the sodium bicarbonate type, water toward the southeast part of the Silvies fan tends to have a concentration of sodium higher than can be used for irrigation. At the Lawen-Malheur Lake vicinity, most water is of the sodium bicarbonate, sodium bicarbonate-chloride, sodium cloride, sodium sulfide, or calcium sodium bicarbonate type and is too highly mineralized to be of domestic use. Along the east side, water tends to be of the low mineral, sodium bicarbonate type and good quality for most use. Piper and other (1939) report a similar water quality pattern from shallow aquifers and state that shallow valley fill is less suitable for irrigation than deeper waters from valley fill, and bedrock thermal water may be of such quality as to be utilized for various means, especially irrigation. However, deleterious contents such as silica, boron, sodium, and fluorine can preclude use of such waters (Leonard, 1970).

WATER USE

The majority of water use in the Harney Basin is for irrigation, but it is also consumed by industry, municipalities, household, and livestock. Thermal water from the wells in Sec. 34 and 35, T. 22 S., R. 32 E. has also been used to heat a greenhouse for winter food production. Much of the irrigation waters can be obtained by diversion of surface waters through "wild flooding," but a substantial amount of all waters must be obtained from ground water, particularly during dry years (Table 4).

Table 4. Estimated use of ground water in the Harney Valley, 1968 and 1969. (From Leonard, 1970).

	Pumpage in acre-feet (hm^3)	
Use	1968	1969
Irrigation	10,700 (13)	7,900 (9)
Municipal	1,100 (1)	930 (1)
Industrial	5,000 (6)	4,000 (5)
Rural	100 (.1)	160 (.1)
Total	16,900 (20.1)	12,930 (15.1)

Surface water rights in the Harney Valley are already over appropriated, and in dry years some individuals are unable to obtain irrigation waters although they may hold rights. There is no curtailment on subsurface water rights, but the number of irrigation wells are self regulating in that the well cost must be retrieved through the benefit of additional yield of the low profit crops grown, a low frequency situation (Leonard, per. com., 1976). However, many irrigation wells are reportedly being drilled in the northeast part of the valley and east of Crane in the response to tax incentives (Leonard, pers. com., 1976).

The Malheur Lake marsh is considered a wildlife refuge and the U.S. Fish and Wildlife Service has expressed concern over its preservation. It is felt that alternatives to any water resource management in the Harney Valley should be studied prior to initiating water diversion actions due to the apparent delicate hydrologic balance that now exists, and that additional upstream water removal which reduces inflow into the lake could seriously affect the wildlife situation in the marsh area.

ADDITIONAL WATER AVAILABILITY

In subdividing the Harney Valley (Fig. 5.), Leonard (1970) discussed the availability of ground water for future development and determined that large quantities are available for use in parts of the valley. However, certain limitations restrict development and include; 1) interference between wells causing pumping depressions, such as southeast of Burns and in the area of Sec. 28, and 29, T. 23 S., R. 32 E.; 2) abrasive sand content of pumped water which causes equipment failure; 3) overdrafting, as exemplified in the Hines warm-water area and potentially identified at Crane; and 4) quality (as previously discussed).

For the most part, Leonard (1970) reports that good yielding wells of suitable quality can be produced in most places in the Sagehen and northern Silvies-Fan subareas (Fig. 5). Prospects are fair in the southern Silvies and central-valley subareas. The potential for development is erratic and unpredictable in the north-side subarea east of Prater Creek. The east-side subarea has undergone considerable development with respect to the alluvial aquifer, but potential exists for tapping a deeper source. Except for the western part of Sunset Valley, the southern and south-western parts of the valley show little potential for development.

GEOTHERMAL WATER DEMAND

Outside water demand for geothermal operations varies with the size of the field and usage. Geothermal waters can be simply circulated through a closed system and then injected into the subsurface after use without a need for outside water. In electrical generation, the amount of additional water will vary according to the type of power plant utilized (Table 5).

Table 5. Estimated water demand for geothermal operations.

OPERATION	WATER DEMAND /1
Exploration /2	3.7 acre-ft/yr (.0046 hm^3)
Development /2	3.7 acre-ft/yr (.0046 hm^3)
Power Plant Operation /3	
Isobucane Power Plant	-3,100 acre-ft/yr (3.8 hm^3)
Direct Steam Power Plant	+ 430 acre-ft/yr (.5 hm^3)
Flashed Steam Power Plant	- 200 acre-ft/yr (.25 hm^3)

/1 + Water in excess in Geothermal Operations.

- Water required from either produced water or outside source.

/2 Assuming 20 producing wells required per power plant.

/3 Water demand on basis of a 55 MW generator and a well-head temperature of 405°F (207°C).

Note that use of a direct steam power plant (Fig. 7) actually results in emanation of excess water while an isobutane (Fig. 8) or flashed steam power plant Fig. 9) requires cooling water either produced from the operation or from an outside source.

On the basis of our current understanding of geothermal development, an average geothermal field could consist of two to three power plants, producing 100 to 160 MW per year. If a direct steam power plant is used, a water excess of about 860 to 1,290 acre-feet (1 to 1.6 hm^3) would occur while a flashsteam operation would require almost 400 to 600 acre-feet (.5 to .7 hm^3) of annual make-up water. For the largest consumptive geothermal operation, the isobutane plant, estimated make-up demand would range from approximately 6,200 to 9,300 acre-feet (7.6 to 11.4 Km^3).

Blow-down water produced by the cooling cycle in the isobutane system, approximately 97 acre-feet (.1 hm^3) per year per plant, may be injected. The difference between the make-up water and the blow-down fluid, approximately 3,000 acre-feet (3.7 hm^3) per year per plant, is lost through evaporation. The high concentration of dissolved solids in the returned fluid precludes a re-cycling and its use as make-up water. It is important to note that these cooling water requirements need not necessarily come from local surface reservoirs or water wells, but may be obtained wholly from produced geothermal waters. However, the ultimate source of geothermal waters is precipitation and recharge in the drainage basin. Therefore, the production of geothermal waters has the same long-term hydrologic impact as use of any other ground water in the basin. The final choice to use either local or produced water would depend on availability of local water and a comparison of the quality, characteristics, and economics of each source.

CONCLUSIONS

It appears from the foregoing data that an undefined potential exists to further develop ground water resources within the Harney basin and such has been indicated by Robison (1968). According to Leonard (1970), except for a small east side area which shows signs of overdevelopment, ground water could sustain considerable additional development in the valley area north of Malheur Lake. Indeed, if actual use of underground water is less than 20,000 acre-feet (25 hm^3) per year and annual recharge is near that which appears estimated for the basin [170,000 acre-feet (200 Km^3)] or parts of the valley [40,000 to 60,000 acre-feet (50 to 75 Km^3)], it seems reasonable to assume that sufficient water would be available for geothermal operations, if needed. However, water availability with respect to site-specific points may present problems in many areas due to the unpredictability of water productive reservoirs, mainly as a result of the erratic lateral variability of beds from aquifer to non-aquifer character.

Figure 7. Geothermal Power Plant Direct Steam

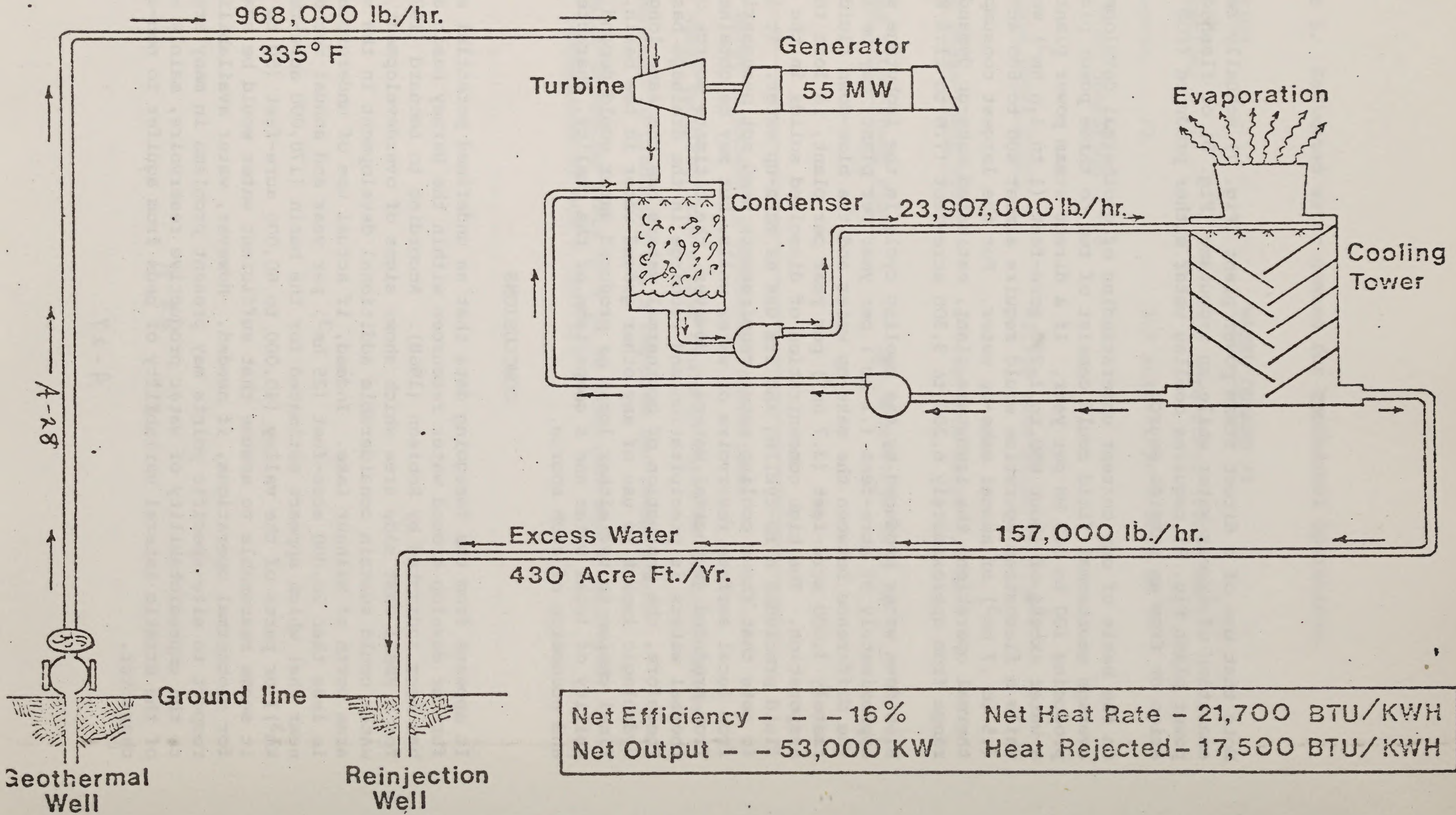


Figure 8. **Isobutane Cycle**

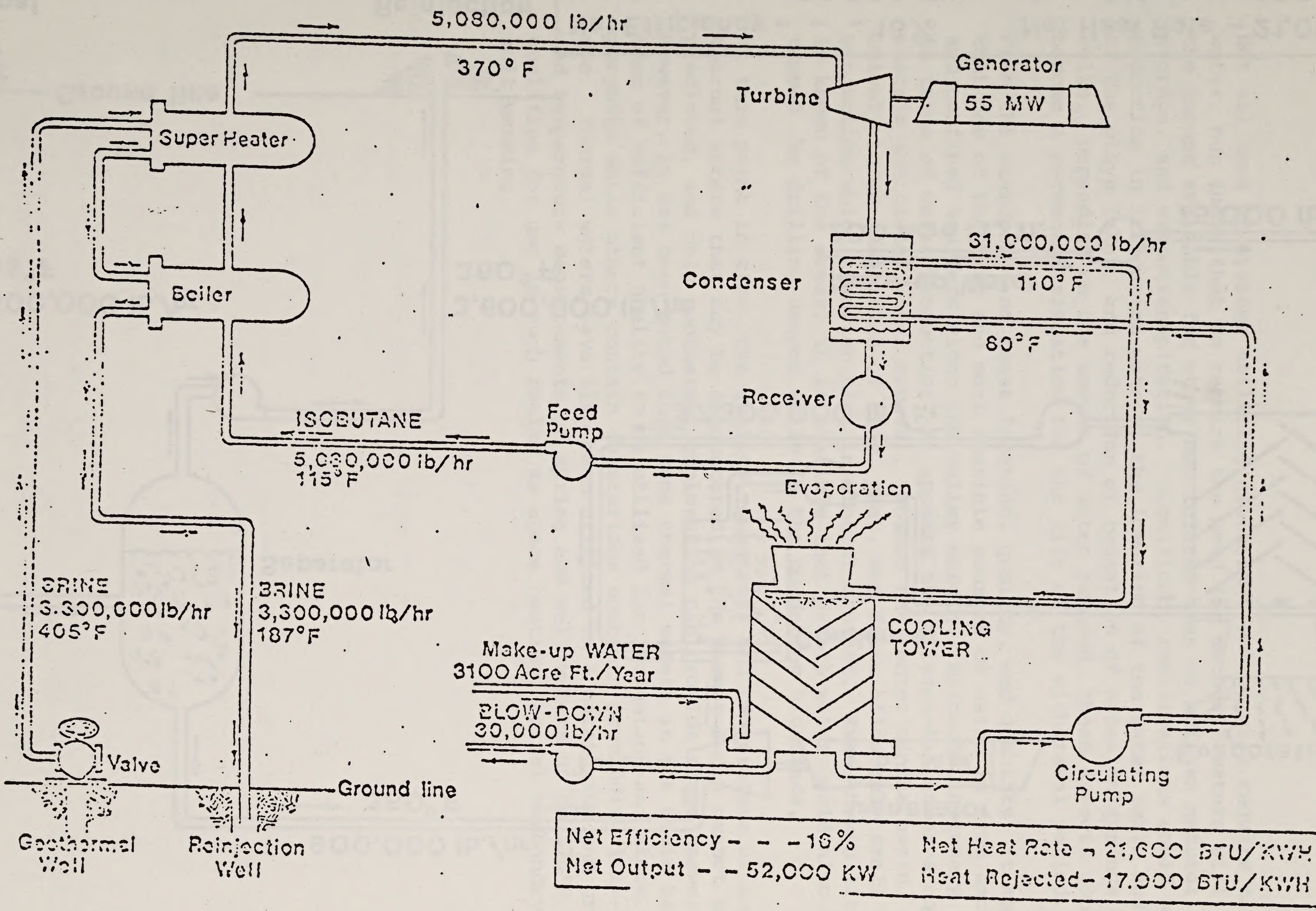
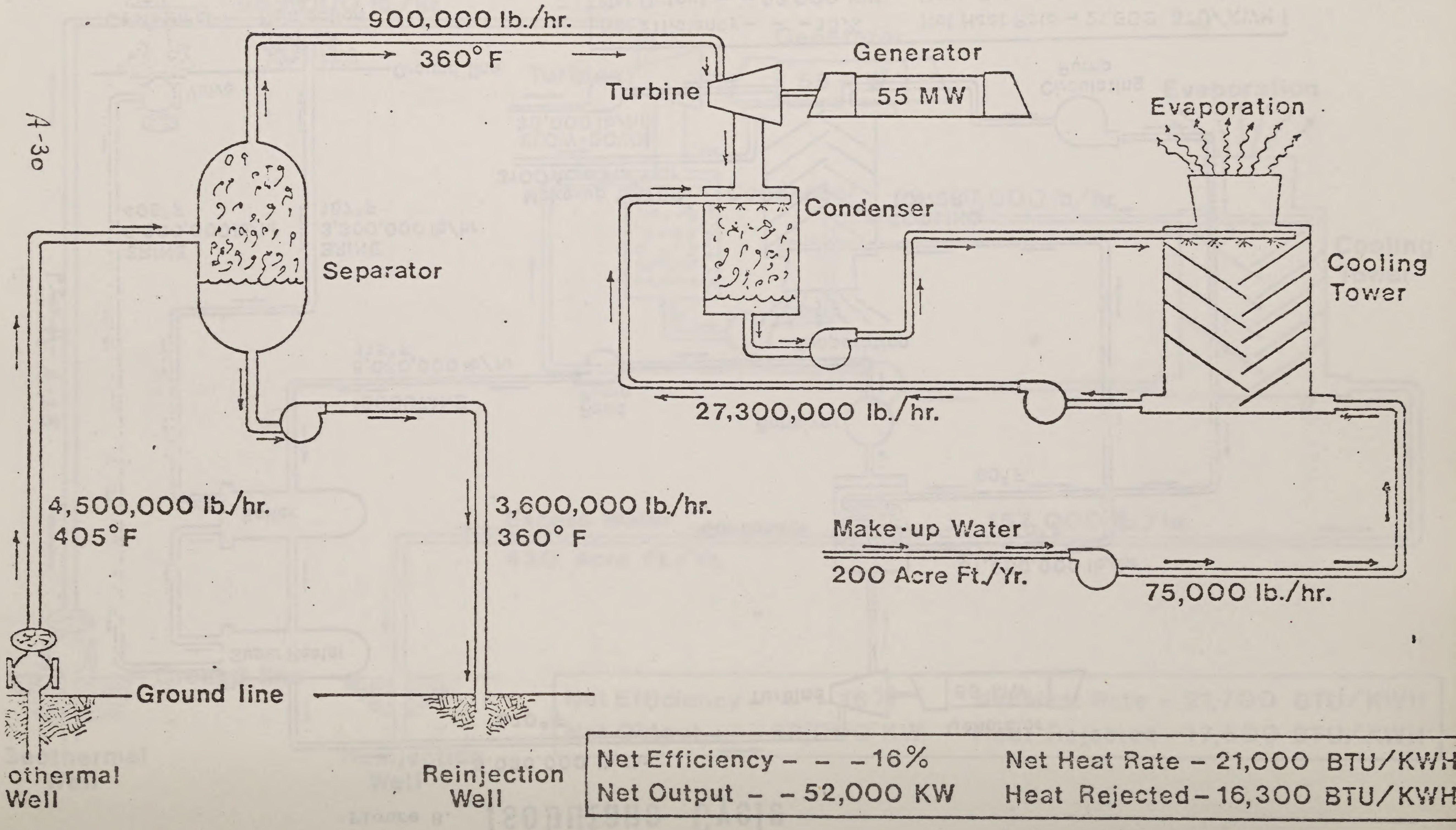


Fig. 3 -- Schematic of Plant Cycle Used in Computing Geothermal Water Demand.

Figure 9. **Geothermal Power Plant Flashed Steam**



Not all uses or systems utilizing geothermal energy will require make-up water, but those that do require the need for meteoric waters will reduce the amount available for other man related uses as well as natural runoff, storage, and evapotranspiration. Significant ramifications could be reduction in irrigation waters, the lowering of the water table and levels of the playa lakes, and reduction or cessation of artesian springs and wells. Depending on the amount of water removed, these aspects could become a permanent situation for the life of the withdrawal period.

From the standpoint of lease location, quality, and quantity, it appears that one of the best and most feasible sources of water is from unconfined and confined aquifers along the valley margin. Although intensely used in terms of water production, it appears the Silvies-Fan subarea could sustain additional water removal. Toward the center of the basin, relatively large quantities of clay, peat, and fines allow only small water production which is often high in mineral content. Even though little is known of the areas, it is possible that usable water could also be tapped by drilling deeper wells in the bordering highlands.

At this point in time, the quality, quantity, and temperature of any geothermal waters that may be encountered in the Harney Basin cannot be predicted, and only geothermal exploration can provide these answers. However, it has been noted that some thermal waters in the basin have been of sufficient quality to be utilized for irrigation and stock watering purposes while others contain deleterious contents precluding life-supportive use. Thermal waters have also been utilized in a natatorium and greenhouse, and temperature measurements of spring and well waters up to 176°F (80°C) qualifies for use in such realms as space heating, animal husbandry, and soil warming.

TEMPERATURES REQUIRED FOR
VARIOUS GEOTHERMAL APPLICATIONS *

Temperature range of conventional power production (190–180 °C)

Present expected temperature range for binary power plants (185–160 °C)

Saturated Steam (200–110 °C)

Water (120–20 °C)

°C	
200	
190	
	Evaporation of Highly Concentrated Solutions
180	Refrigeration by Ammonia Absorption
	Digestion in Paper Pulp
170	Heavy Water via H_2S Processing
	Drying of Diatomaceous Earth
160	Drying of Fish Meal
	Drying of Timber
150	Alumina Via Bayers Process
140	Drying Farm Products at High Rates
	Canning of Food
130	Evaporation in Sugar Refining
	Extraction of Salts by Evaporation and Crystallization
120	Fresh Water by Distillation. Most Multiple Effect Evaporations, Concentration of Saline Solutions. Refrigeration by Medium
110	Temperatures
	Drying and Curing of Light Aggregate Cement Slabs
100	Drying of Organic Materials, Seaweeds, Grass, Vegetables, etc.
	Washing and Drying of Wool
90	Drying of Stock Fish
	De-Icing Operations
80	Space Heating
	Greenhouses by Space Heating
70	Pasteurization (harmful bacteria killed at 74.4°C or 166°F)
	Refrigeration by Low Temperatures
60	Animal Husbandry
	Greenhouses by Combined Space and Hotbed Heating
50	Mushroom Growing
	Balneological Baths
40	Soil Warming
30	Swimming Pools, Biodegrading, Fermentating
	Warm Water for Year-around Mining in Cold Climates. De-Icing
20	Hatching of Fish. Fish Farming.

*adapted from Geothermal Energy for Process Use by Baldur Lindal in Study Guide from International Conference on Geothermal Energy for Industrial, Agricultural and Commercial-Residential Uses. Klamath Falls, Oregon, October 7-9, 1974.

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APPENDIX I

Hydrologic Data for Representative Wells in the Harney Basin (from Piper and others, 1939)

Appendix I. Hydrologic data for representative wells in the Harney basin. (From Piper and others, 1939)

[Use of water --D, domestic; Ind, industrial; Ir, irrigation; P, public service; R, railroad; S, stock].

Location	Owner	Depth (feet)	Diameter	Geologic horizon of water-bearing bed [1]	Measuring point: Description	Measuring point: Above or below land surface (feet)	Measuring point: Altitude above sea level (feet)	Observed extremes of ground-water stage, 1930 (feet below measuring point): Lowest	Observed extremes of ground-water stage, 1930 (feet below measuring point): Highest	Use	Temperature (°F.)	Remarks
T. 22 S., R. 31 E.												
NW¼NE¼ sec. 25	Charles Richmond	490	10 in	[2]	Top of casing	+0.5	4,180	24.65	10.05	None		"Dry hole"; penetrates "shale" of Danforth formation from 35 feet to 490 feet.
SW¼NW¼ sec. 27	Unknown	10	5 ft	Qal	Top of platform	.0	4,173	8.40	[3] 2.55	S		
SW¼NE¼ sec. 34	---- Baker	9		Qal	do	+1.0	4,157	8.05	[3] 6.45	S		
SW¼SW¼ sec. 34	Frank Whiting	288	18 to 8 in	Td	Top of casing	+1.0	4,151	13.15	3.35	S		
NW¼NE¼ sec. 36	Charles Walker	228	24 to 18 in	Td	do	+1.5	4,153	6.90	[3] 5.60	None		
NE¼NW¼ sec. 36	L. S. Hebener	36	18 in	Qal	do	+1.0	4,155	15.25	12.25	S		
T. 22 S., R. 32 E.												
NE¼SE¼ sec. 25	Alex Rogers	11	5½ ft	Qal	Top of platform	+.5	4,147	10.25	3.50	D	53	Uncased.
NE¼NW¼ sec. 34	William Krzeska	14	6 ft	Qal	do	.0	4,144.5	11.75	10.70	None	46	Do.
NW¼NE¼ sec. 36	Frank Triska	44	6 in	Qal	Top of casing	+.6	4,133	10.85	4.45	D		Cased 44 feet.
do	do	16	8 in	Qal	do	+2.0	4,134	11.35	11.15	None		Casing pulled and well filled up in May, 1931.
T. 22 S., R. 32½ E.												
NE¼NW¼ sec. 36	I. L. Poujade	14	5 ft	Qal	Top of platform	.0	4,143	13.40	9.30	do		Uncased.
T. 22 S., R. 33 E.												
NE¼NE¼ sec. 34	Unknown	22	6 by 6 ft	Qal	[2]	+1.0	4,166	14.75	9.25	D		Measuring point, top of 12- by 12-inch timber.
T. 23 S., R. 30 E.												
NE¼SE¼ sec. 12	City of Burns	251	12 in	Td	Pressure gage	+4.5	4,233.7			P	57	Cased 151 feet.
do	do	251	12 in	Td	do	+4.5	4,233.7			P	58	Do.
do	Unknown	115	4 in	Td	Top of casing	−5.0	4,215.70	74.55	73.65	None		Cased 40 feet.
NE¼SE¼ sec. 23	Stafford, Derbes & Roy. Co.	170	6 in	Td	[1]	+.8	4,159.45			P		Cased 100± feet. Measuring point, top of casing collar.
NE¼SW¼ sec. 23	City of Hines	340	12 in	Td	Pressure gage	.0	4,314.9			P	62	
NE¼NE¼ sec. 24	Harney County fair grounds.	16	2 in	Qal	Top of casing	+1.8	4,149	6.40	4.35	None		Filled within 5 feet of the top during winter of 1930-31.
NE¼SE¼ sec. 26	Edward Hines Western Pine Co.	171	10 in	Qbh						Ind	76	Cased 100 feet. Flowed 200 gallons a minute when drilled.
do	do	152	10 in	Qbh						Ind		
do	do	78	18 in	Qal	do	+1.0	4,148			None		Filled up to 53 feet.
T. 23 S., R. 31 E.												
SW¼SW¼ sec. 1	---- Davidson	400	8 in	Td?	do	−8.4	4,135.28	7.51	2.90	S		
do	do	22	5 ft	Qal	[2]	.0	4,144.28	14.05	13.30	None		Measuring point, top of 6-inch casing in dug portion.
Lot 4, sec. 2	P. G. Williams	350	6 in	Td	Top of platform	.0	4,150	11.50	[7] 11.00	S		No casing.
NW¼SW¼ sec. 2	Unknown	13	4 by 6 ft	Qal	Top of curb	+1.5	4,145	11.70	10.00	None		Do.
Lot 4 sec. 3	Unknown	33	18 in	Qal	Top of casing	+1.0	4,151	9.30	9.30	do		
NW¼SW¼ sec. 3	R. E. Peabody	123	18 in	Qal	do	.0	4,150	9.40	6.45	Ir	55	Cased 45 feet. Irrigates 2-acre garden.
do	do	122	4 in	Qal	do	+.2	4,149	8.50	8.50	D		Cased 67 feet.
Lot 2 sec. 4	L. M. Hamilton	98	18 in	Qal	do	+1.0	4,153	13.43	8.15	None	52	Cased 50 feet,

[Use of water—D, Domestic; Ind, Industrial; Ir, Irrigation; P, public service; R, railroad; S, stock]

Location	Owner	Depth (feet)	Diameter	Geologic horizon of water-bearing bed [1]	Measuring point: Description	Measuring point: Above or below land surface (feet)	Measuring point: Altitude above sea level (feet)	Observed extremes of ground-water stage, 1930 (feet below measuring point): Lowest	Observed extremes of ground-water stage, 1930 (feet below measuring point): Highest	Use	Temperature (°F.)	Remarks
Lot 4 sec. 4	S. Hoez	41		Qal	Top of platform	+1.0	4,156	15.35	10.10	D		
SW¼SW¼ sec. 4	L. M. Hamilton	15	4½ ft	Qal	do	.0	4,152	11.50	[9] 1.95	Ir		Irrigates small garden.
Lot 3 sec. 5	William Hanley Co.	42	3 feet	Qal	(2)	+2.0	4,162	16.88	8.65	D		Measuring point, copper washer in top of well cover.
SW¼SW¼ sec. 5	A. B. Cooley	12	3 by 5 ft	Qal	Top of platform	+.5	4,153	8.90	[9] 3.55	S		No casing.
Lot 5 sec. 6	Charles Frazier	14	3 in	Qal	Top of pump support.	+1.8	4,166	12.65	5.65	D	50.5	Do.
Lot 3 sec. 7	—— Hansen	14	4 in	Qal	Top of casing	+2.3	4,157	13.12	9.40	None		
SE¼SW¼ sec. 7	Archie McGowan	125	3 in	Qal(?) or Td.	(2)	.0	4,150	8.93	7.72	do		Measuring point, concrete floor of garage.
do	Unknown	31	2 in	Qal	Top of casing	+4.0	4,153	12.45	11.00	do		
Lot 4 sec. 7	Matt Riggs	10	8 in	Qal	Top of pump support.	.0	4,150	[9] 10.2	4.50	do		No casing.
NE¼SW¼ sec. 8	Unknown	10	1½ in	Qal	Lower valve seat	+3.0	4,152	10.20	3.75	do		
Lot 2 sec. 8	H. B. Mace	140	6 in	Qal						D		Cased 126 feet.
SW¼SW¼ sec. 9	Burns Airport	25	4½ in	Qal	Top of casing	+.3	4,150.19	13.55	5.06	D		
SE¼SE¼ sec. 9	George Whiting	12		Qal	Top of platform	+.2	4,144.59	[3] 10.68	[3] 1.72	S	49	No casing.
SE¼SE¼ sec. 9	do	43	1½ in	Qal	Lower valve seat	+2.5	4,147.45	12.60	12.60	D	51.5	
NE¼NW¼ sec. 10	Unknown	13	10 in	Qal	Top of casing	+2.0	4,148	[10] 13.53	[10] 8.00	S		
NE¼NE¼ sec. 13	Obid Shattuck	325	6 in	Qal and Th (?).	do	+1.9	4,141.15	[11] 25.72	10.80	None		So-called County well. Flowed at original depth of 818 feet.
do	do	28	6 by 6 ft	Qal	(2)	+1.9	4,141.15	14.90	14.15	do		Dug around well 53; cribbed 18 feet with wood. Measuring point, top of casing of well 53.
NE¼NW¼ sec. 13	Unknown	16		Qal	Top of pump flange.	+2.3	4,141	17.25	16.65	S		
SW¼NW¼ sec. 13	J. S. Cook	105	18 in	Qal	Top of pump base	.0	4,142.80	[12] 77.9	12.00	Ir	52	Cased 84 feet.
NE¼NE¼ sec. 14	Geological Survey	12½	4 in	Qal	Top of casing	+.7	4,140.70	11.50	9.92	None		Cased 3 feet.
do	do	12	4 in	Qal	do	+.4	4,142.83	13.00	8.83	do		Do.
NW¼NE¼ sec. 14	do	12½	4 in	Qal	do	+.5	4,142.83	13.00	4.97	do		Do.
do	do	12	4 in	Qal	do	+.7	4,141.96	12.05	3.57	do		Do.
NE¼NW¼ sec. 14	Unknown	28	6 in	Qal	do	+1.0	4,144.50	14.01	11.64	S	50	
NW¼NE¼ sec. 15	William McLaren	16	18 in	Qal	do	+.2	4,141.90	9.81	1.70	D		Irrigates small garden.
do	do	52	18 in	Qal	Top of girder	+.5	4,141	9.50	9.20	None		Well filled up in September 1930.
do	do	87	18 in	Qal	(2)	+.1	4,141.92	11.48	1.90	Ir	51.5	Cased 53 feet. Measuring point, bottom of ½-inch drilled hole in casing.
SW¼NE¼ sec. 16	Pacific Live Stock Co.	300	12 to 8 in	Th (?)	Top of pump base	.0	4,145.58	13.36	5.19	Ir	58.5	Cased 300 feet.
NW¼NE¼ sec. 17	Geological Survey	10	3 in	Qal	Top of casing	+.6	4,147.75	10.73	.57	None		Cased 3 feet.
NE¼NW¼ sec. 17	do	11	4 in	Qal	do	+.8	4,147.26	8.40	.01	do		Do.
Lot 6 sec. 17	do	10	4 in	Qal	do	+.8	4,147.42	8.68	.01	do		Cased 7 feet.
do	do	12	4 in	Qal	do	+1.0	4,150.49	11.05	.88	do		Cased 3 feet.
do	do	11	4 in	Qal	do	+.5	4,151.05	11.92	.81	do		Do.
Lot 1 sec. 18	L. Vickers	13		Qal	Top of cover	.0	4,152	9.05	8.35	S		
do	C. H. Voegtly	13	6 by 6 ft	Qal	do	+.7	4,152	10.82	8.89	D		
Lot 2 sec. 18	Oregon Short Line R. R. Co.	110	12 in	Qal						R		Cased 100 feet.
SE¼NW¼ sec. 18	C. E. Sillaugh	106	12 in	Qal						Ir	54	Cased 106 feet.
T. 23 S., R. 31 E.												
NE¼NE¼ sec. 20	Charles Culp	195½	6 in		Top of casing	+3.5	4,148	11.15	10.20	None		
Lot 1 sec. 20	do	63½	24 in	Qal	do	+.8	4,147.79	3.46	12.13	do		
do	Geological Survey	15	18 in	Qal	do	+1.0	4,147.67	2.12	11.81	do		Cased 3 feet.
SW¼NW¼ sec. 20	Charles Culp	16½	6 in	Qal	(2)	+1.3	4,147.01	10.00	3.70	D		Measuring point, top of plank on 8- by 14-inch timber.
SE¼NE¼ sec. 21	William Hanley Co.	54	4 in	Qal	Top of casing	.0	4,139	7.70	.55	D	50	Cased 54 feet.
do	do	13	1½ in	Qal	Lower valve seat	+2.7	4,143	11.80	4.20	D	47	
do	do	97	2 in	Qal	do	+2.7	4,143	11.00	4.00	D		
SE¼SE¼ sec. 23	do	55½	4 in	Qal	Top of casing	+.5	4,136.44	11.80	9.63	S		
NE¼NE¼ sec. 24	—— Brown	78	2 in	Qal	do	−4.4	4,135	12.00	12.00	S		
SE¼NW¼ sec. 24	Unknown	10½	4 by 5 ft	Qal	Top of cover	.0	4,137	Dry	1.65	S		No casing.
NW¼NW¼ sec. 28	Charles Culp	45	8 in	Qal	Top of casing	+1.7	4,139.20	10.40	2.65	S		Land-surface altitude 4,137 feet at well No. 86 used as datum.
do	do	9	4 by 4 ft	Qal	(2)	−.5	4,137	8.80	.10	None		Measuring point, copper washer in top of 2- by 12-inch plank.
Lot 1 sec. 30	—— Hotchkiss	11½	1½ in	Qal	Top of casing	+3.0	4,142	5.50	2.00	do		
NW¼NE¼ sec. 32	C. W. Mace	295	6 in		(2)	+1.0	4,134	7.40	2.50	S		Cased 295 feet. Measuring point, copper washer in top of wooden pump clamp.
NE¼SE¼ sec. 32	Newton Hotchkiss	38	2 in	Qal	Top of casing	+1.1	4,137	12.20	11.05	D		Cased 38 feet.
NW¼SW¼ sec. 32	O. D. Hotchkiss	10	1¼ in	Qal	Lower valve seat	+2.2	4,131	10.55	8.10	None		
SE¼NW¼ sec. 35	William Hanley Co.	72	4 in	Qal	Top of casing	+1.0	4,134	10.15	9.25	do		

[Use of water—D, Domestic; Ind, Industrial; Ir, irrigation; P, public service; R, railroad; S, stock]

Location	Owner	Depth (feet)	Diameter	Geologic horizon of water-bearing bed [1]	Measuring point			Observed extremes of ground-water stage, 1930 (feet below measuring point)		Use	Temperature (°F.)	Remarks
					Description	Above or below land surface (feet)	Altitude above sea level (feet)	Lowest	Highest			
T. 23 S., R. 32 E.												
Lot 3 sec. 6	Unknown	19½	5 ft	Qal	Top of girder	.0	4,138	15.60	12.45	do	46	No casing.
NE¼SW¼ sec. 7	Harney Branch Experiment Station.	11½	4 in	Qal	Top of casing	+.4	4,135.6	9.70	6.50	do		
do	do	87	18 in	Qal	Pressure gage	+1.4	4,136.8	[11] 40.00	6.00	Ir	48	Cased 60 feet.
SW¼SE¼ sec. 7	do	218	8 in	Ta	do	+.7	4,137.4	[11] 28.20	7.60	Ir	58	Cased 170± feet.
do	do	11	4 in	Qal	Land surface	.0	4,136	10.40	8.20	None		No casing.
NW¼NW¼ sec. 8	Unknown	45	1½ in	Qal	Top of casing	+1.5	4,134.95	[11] 18.39	8.68	do		
SE¼SE¼ sec. 8	F. O. Jackson	14	2 in	Qal	Lower valve seat	+2.5	4,133	13.65	13.30	do	54	
NE¼NW¼ sec. 10	Unknown	33	6 in	Qal	Top of curb	+1.5	4,133	12.19	11.24	do	50	
SW¼NE¼ sec. 12	do	18½	4 by 6 ft	Qal	Top of girder	.0	4,128	11.00	9.80	do		
SW¼NW¼ sec. 16	Dr. Horton	800±	6 in		Top of casing	+.5	4,132	6.00	5.55	do		
NW¼SW¼ sec. 17	B. L. Allen	59	24 in	Qal	do	+1.0	4,132	12.47	11.90	None		
do	do	53	8 in	Qal	do	.0	4,135.70	[11] 21.11	11.35	do		
SE¼SE¼ sec. 17	do	52	8 in	Qal	do	+1.0	4,134	18.26	12.75	D		
Lot 2 sec. 18	Fred Denstedt	565	3 in		(?)	+.5	4,137.89	[11] 21.27	9.34	None		Measuring point, copper washer in top of curb.
do	do	24	18 in	Qal	Top of casing	.0	4,138.65	12.80	12.80	S		
do	do	60	6 in	Qal	(?)	+.5	4,138.85	[11] 23.40	8.72	None		Measuring point, copper washer in top of curb.
SE¼SE¼ sec. 19	R. W. Cozad	39	6 in	Qal	Top of casing	+.3	4,132.98	[11] 21.17	9.72	D		
NW¼NW¼ sec. 20	Curtis Smith	15	4 by 5 ft	Qal	Top of platform	+1.2	4,134	13.75	13.75	S		
SW¼SW¼ sec. 20	R. W. Cozad	15½		Qal	Top of cover	+.5	4,132.60	14.49	10.40	D	52	Irrigates lawn.
do	do	44	2 in	Qal	Lower valve seat	+4.0	4,135.27	[11] 31.70	16.22	D	50	
do	do	72	24 in	Qal	Top of pump base	−.4	4,132.75	[12] 22.85	9.90	Ir	52	
SE¼SE¼ sec. 20	D. N. Varien	47	2 in	Qal	(?)	−8.5	4,121.39	[11] 10.87	7.37	D		Measuring point, top of tee joint of casing.
do	do	12½	6 by 8 in	Qal	Top of casing	+3.0	4,137	14.30	7.30	S		
NW¼NW¼ sec. 21	—— Woods	12½	8 in	Qal	Top of pump base	+2.3	4,135	13.80	13.30	S		
NE¼SE¼ sec. 22	Unknown	20	6 by 6 ft	Qal	Top of cover	+.5	4,127	16.25	16.25	S		
NW¼NE¼ sec. 27	do	11	4 by 4 ft	Qal	Top of curb	+2.0	4,130	13.65	13.00	D	50	
NE¼NE¼ sec. 28	Dubaime Bros.	12	4 by 4 ft	Qal	Top of cover	+.8	4,130	13.25	5.75	S		
do	do		18 in	Qal								
NW¼NW¼ sec. 28	do	135	24 in	Qal	Top of casing	.0	4,129	21.40	15.65	None		Cased 90 feet.
SE¼SE¼ sec. 32	Unknown	12½	8 in	Qal	(?)	+.2	4,128	Dry	11.30	do		No casing. Measuring point, top of bucket in top of well.
NE¼NW¼ sec. 35	do	13	6 ft	Qal	Top of curb	+.7	4,125	13.30	12.85	D		Do.
T. 23 S., R. 32½ E.												
Lot 4 sec. 2	do	15	6 by 6 ft	Qal	Top of cover	+1.2	4,131	[14] 14.10	4.95	S		
SW¼SE¼ sec. 2	do	19	6 by 6 ft	Qal	do	+.8	4,130	13.15	13.15	D		Cased 10 feet.
Lot 1 sec. 6	Unknown	15	5 ft	Qal	do	.0	4,129	13.00	4.75	S		No casing.
SE¼NE¼ sec. 6	Jim Gibson	16	6 ft	Qal	Top of curb	+2.4	4,131	16.20	15.95	D		Cased 10 feet.
Lot 1 sec. 31	Henry Anderson	52	2 in	Qal	Top of cover	+.1	4,119	19.05	19.05	S	51	
do	do	18		Qal	Lower valve seat	+.7	4,120	18.00	16.60	D	50	
SE¼NE¼ sec. 32	—— Haines	21	6 by 6 ft	Qal	Top of pump support.	+.8	4,118	16.55	16.55	S		
NW¼SE¼ sec. 32	H. C. Bush	24	2 in	Qal	Lower valve seat	+2.6	4,121	21.50	19.70	D	52	Cased 24 feet.
NE¼NW¼ sec. 35	Unknown	20	6 by 6 ft	Qal	Top of platform	+1.0	4,120	[14] 14.30	12.35	S	49	
NE¼SW¼ sec. 36	do	22	6 in	Qal	Top of plank	.0	4,121	11.90	11.50	S		
T. 23 S., R. 33 E.												
SE¼SW¼ sec. 3	Unknown	11½	8 ft	Qal	Top of cover	.0	4,134	11.40	4.25	S		No casing.
Lot 4 sec. 6	State Board Land Co.	18	10 ft	Qal	do	+1.0	4,135	11.35	11.35	S		
NE¼SW¼ sec. 22	State of Oregon	18½	8 ft	Qal	do	+.2	4,130	[4] 18.15	11.70	S	52	
NE¼NW¼ sec. 33	do	16	6 by 6 ft	Qal	do	.0	4,128	14.40	11.10	S		
T. 21 S., R. 30 E.												
Lot 2 sec. 1	J. C. Clemens	478	12 to 10 in	Qb or Td						Ir	80	Cased 117 feet. Flowing when visited. Flow estimated between 300 and 400 gallons a minute.
Lot 4 sec. 1	—— Brown	60	3 in	Qal						S	64	Flows a trickle 2½ feet above land surface.
Lot 1 sec. 2	Unknown	83½	2 in	Qb (?)	Lower valve seat	+.9	4,136	2.40	1.15	Ir		Irrigates garden. Flowed until about July 1, 1930.
Lot 2, sec. 2	H. Wunbsgan	80	2 in	Qb or Td.	Top of platform	+4.0	4,142	10.25	10.25	D	82	
SE¼NE¼ sec. 2	do	15	10 in	Qal	Top of cover	.0	4,135	7.45	6.90	None	54	No casing.
NE¼NE¼ sec. 18	Unknown	33	5 ft	Qal						S		Water turbid with suspended matter. No casing.
T. 21 S., R. 31 E.												
Lot 6 sec. 1	do	44	2 in	Qal	Lower valve seat	+3.0	4,134	13.35	13.50	None		
Lot 4 sec. 2	William Hanley Co.	60½	2 in	Qal	do	+3.2	4,131	13.50	12.30	S		

[Use of water—D, Domestic; Ind, industrial; Ir, irrigation; P, public service; R, railroad; S, stock]

Location	Owner	Depth (feet)	Diameter	Geologic horizon of water-bearing bed [1]	Measuring point			Observed extremes of ground-water stage, 1930 (feet below measuring point)		Use	Temperature (°F.)	Remarks
					Description	Above or below land surface (feet)	Altitude above sea level (feet)	Lowest	Highest			
SE¼SW¼ sec. 6	Unknown	47	2 in	Qal	Top of casing	+2.5	4,133	3.45	2.45	None		
SW¼SE¼ sec. 6	do	10	8 in	Qal	Bottom of pump base.	+1.2	4,131	9.55	6.20	S		No casing.
NE¼NE¼ sec. 8	do	48	4 in	Qal	do	.0	4,128	4.95	3.00	None		
SE¼NE¼ sec. 8	do	41½	2 in	Qal	do	+1.6	4,129.85	6.95	3.80	D	54	Land-surface altitude 4,128 feet at well No. 160 used as datum.
do	do	10	3 in	Qal	Top of cover	.0	4,128	10.00	1.30	None	46	Well found caved July 7, 1932.
SW¼NW¼ sec. 9	do	52	2 in	Qal	Top of casing	+2.2	4,130	7.10	7.10	do		
do	do	42	2 in	Qal	do	+1.0	4,128	6.40	4.85	S		
SE¼SW¼ sec. 10	Mrs. John Creasman.	11	6 by 6 ft	Qal	Top of cover	+1.0	4,127	12.95	3.65	S	51	
SW¼SW¼ sec. 12	Unknown	11	6 by 6 ft	Qal	(²)	+.3	4,126	10.05	1.55	S		Measuring point, copper washer in top of log girder.
NE¼SE¼ sec. 29	Larsen ranch	53	2 in	Qal	Top of casing	+2.5	4,126.50	12.50	9.70	S	51	Land-surface altitude 4,124 feet at well No. 166 used as datum.
do	do	11	3 by 5 ft	Qal	Top of wood curb	+1.0	4,125	Dry	3.25	None	46	
SE¼SE¼ sec. 27	Unknown	10½	6 by 6 ft	Qal	Top of cover	.0	4,116	9.10	8.85	do		No casing.
T. 24 S., R. 32 E.												
Lot 3, sec. 2	Unknown	73	4 in	Qal	(²)	−.8	4,121	20.25	20.25	None		Measuring point, top of casing-flange connection.
SW¼SW¼ sec. 4	O. L. Gasch	69	8 in	Qal	(²)	+.3	4,124	16.95	15.10	Ir		Irrigates garden. Cased from 22 to 62 feet. Measuring point, copper washer in wood curb.
NE¼SE¼ sec. 5	E. Woods	51	2 in	Qal	(²)	.0	4,125	17.15	16.05	None	50	Measuring point, copper washer in wood curb.
SW¼SE¼ sec. 6	Unknown	105	10 in	Qal						do		
NW¼SE¼ sec. 9	Dan Jordan	42	1½ in	Qal	Top of casing	+2.5	4,122	20.70	19.95	do		
SE¼NE¼ sec. 12	Unknown	40	8 in	Qal	Top of platform	.0	4,117	27.75	27.30	S		No casing.
NE¼NW¼ sec. 13	do	33	6 by 6 in	Qal	Top of casing	+.2	4,116	Dry	33.00	None		
NE¼NW¼ sec. 18	do	13	5 by 5 in	Qal	do	+.3	4,119	10.45	9.20	do		
NW¼NE¼ sec. 23	do	57	6 in	Qal	Top of platform	+.3	4,121.15	41.80	39.10	do	52	
SE¼SW¼ sec. 23	Oscar West	46	6 in	Qal	Top of cover	.0	4,114.60	39.25	27.95	S	52	Do.
SE¼SW¼ sec. 26	L. B. Hayes	16	6 by 6 ft	Qal	Top of girder	.0	4,107.30	13.30	5.95	S	49	
NE¼SE¼ sec. 30	Geological Survey	15½	3 in	Qal	Top of casing	+.6	4,112	Dry	12.13	None		Cased 1.5 feet.
do	Pacific Live Stock Co.	39½	2 in	Qal	do	+2.5	4,113.35	15.10	13.90	do		Land-surface altitude 4,111 feet at well 182 used as datum.
SE¼NE¼ sec. 31	do	400	6 in	Th	Top of block	+.2	4,107	8.50	8.50	D	55	
do	do	73½	6 in	Qal	Top of casing	+1.6	4,109	13.15	8.60	None		
do	do	12	6 by 6 ft	Qal	Top of platform	.0	4,107	11.35	4.30	S	48	No casing.
SE¼NW¼ sec. 35		13	2 by 6 in	Qal	Top of casing	+1.6	4,104	Dry	12.60	None		
T. 24 S., R. 32½ E.												
NW¼SE¼ sec. 7	Fred Haines	41	10 in	Qal	Top of pump base	+0.7	4,118	26.20	25.75	S		Cased 10 feet.
NW¼NW¼ sec. 10	Wm. J. Aldridge	40	6 to 4	Qal	Top of cover	+.2	4,121	26.00	25.45	D	54	No casing.
SW¼SW¼ sec. 21	Unknown	42	12 by 12 in	Qal	Top of pump support.	+1.3	4,117.20	40.95	40.00	None		
SE¼SE¼ sec. 30	Ralph Catterson	130±	18 in	Qal	Top of casing	+1.0	4,107.02	32.95	31.55	do		Cased 80 feet. Imperfectly cased allowing water from deep and shallow valley fill to intermingle.
SW¼NW¼ sec. 32	Starr Buckland	180	2 in	Qal						D	57	Cased 100+ feet.
NW¼SW¼ sec. 32	Oregon Short Line R. R. Co.		6 in	Qal						D		
NE¼NE¼ sec. 33	Unknown	35		Qal	do	+.2	4,110.30	31.60	30.45	None		
T. 24 S., R. 33 E.												
SE¼NE¼ sec. 7	— Burke	66	10 in		do	−2.0	4,118	1.10	.55	do		Reported 235 feet deep when drilled. Originally flowed.
Lot 3, sec. 30	C. M. Spencer	105	12 in	Qal	Top of plank	+1.2	4,111	18.20	17.65	D		Cased 40 feet.
do	do	16	6 in	Qal	Top of wood curb	+.7	4,111	Dry	16.50	None		Well went dry during the winter of 1931.
NE¼SW¼ sec. 31	Unknown	21	6 by 6 ft	Qal	Top of casing	−.5	4,119	19.70	18.85	do	54	
T. 24 S., R. 34 E.												
NW¼NE¼ sec. 30	do	16		Qal	Top of platform	.0	4,155	11.90	11.40	S		
SE¼SE¼ sec. 31	do	200+		Ts(?)	Top of coupling	+1.2	4,159	19.62	19.62	None		

[Use of water—D, Domestic; Ind, Industrial; Ir, Irrigation; P, public service; R, railroad; S, stock]

Location	Owner	Depth (feet)	Diameter	Geologic horizon of water-bearing bed [1]	Measuring point: Description	Measuring point: Above or below land surface (feet)	Measuring point: Altitude above sea level (feet)	Observed extremes of ground-water stage, 1930 (feet below measuring point): Lowest	Observed extremes of ground-water stage, 1930 (feet below measuring point): Highest	Use	Temperature (°F.)	Remarks
T. 25 S., R. 28 E.												
SE¼SW¼ sec. 34	Unknown	11	6 ft	Qal	Top of cover	.0	4,128	9.65	9.65	S		Cased 11 feet.
NE¼NE¼ sec. 35	J. U. Côté	12	8 ft	Qal	do	.0	4,128	10.60	10.60	Ir	48	Irrigates garden. No casing.
T. 25 S., R. 30 E.												
SE¼SE¼ sec. 24	Central Oregon Oil & Gas Co.	3,750±		Th in part.						None		Oil prospect.
NE¼SW¼ sec. 35	—— Wilson	28	6 by 20 ft	Qal	[2]	−2.0	4,130	19.8	19.8	do		Oct. 16, 1930, well badly caved. Formerly used for irrigation. Measuring point, top of mud sill of pit frame.
T. 25 S., R. 31 E.												
SE¼SW¼ sec. 9	E. N. Nelson	105	6 in	Th(?)	Top of casing	+1.1	4,124	[14] 15.40	12.45	S	51	
NW¼SW¼ sec. 15	Neva Geer		4 in		do	+.3	4,112	14.00	13.20	None		
SE¼SE¼ sec. 16	School district 14	40±	2 in	Qal(?)	Lower valve seat	+2.2	4,114	16.40	15.70	do		Aug. 5, 1931, well found bridged at 16.5 feet.
SE¼SE¼ sec. 28	Unknown	31	2 in	Qal(?)	do	+1.7	4,113	18.30	17.55	do		
NE¼SE¼ sec. 30	Frank Klitzke	60	4 in	Qal(?)	Top of casing	+1.0	4,186	54.50	54.40	do		
SE¼SE¼ sec. 30	E. Koenemann	107		Qal or Th.						S		
NE¼SE¼ sec. 33	Unknown	22	12 by 12 in	Qal	do	+.8	4,111.55	20.05	20.00	None	56	No casing.
T. 25 S., R. 32 E.												
Lot 1 sec. 2	Pacific Live Stock Co.	43	6 in	Qal	do	+0.2	4,103.35	14.60	11.48	S		
do	do	13	8 by 8 ft	Qal	Top of curb	+2.8	4,105.10	Dry	13.00	None		
Lot 2 sec. 2	do	150	1½ in	Qal	Lower valve seat	+3.0	4,107	9.90	9.90	S		
Lot 3 sec. 2	do	106½	8 in	Qal	Top of casing	+1.0	4,104.25	22.50	12.55	None		
SE¼NE¼ sec. 10	do	47	6 in	Qal	do	+.1	4,098	13.15	13.15	S		
NE¼NW¼ sec. 12	do	45	6 in	Qal	do	.0	4,098	14.00	14.00	S		
SW¼NW¼ sec. 13	do	48½	18 in	Qal	Top of cover	+2.0	4,100	15.55	15.55	S		
SW¼NE¼ sec. 15	do	48	18 in	Qal	do	+2.0	4,098	12.05	12.05	S		
NW¼SE¼ sec. 16	do	49		Qal	Top of timber	.0	4,097	12.25	12.25	S		
SE¼NE¼ sec. 17	do		10 in	Qal	Top of pipe clamp	−.6	4,095	9.45	9.25	S		
Lot 2 sec. 18	Oregon Oil Co	1,000+								None		Oil prospect; well abandoned and casing pulled.
do	Pacific Live Stock Co.	43	10 in	Qal	Top of pump support.	+1.8	4,099	11.40	11.55	S		
NW¼NE¼ sec. 25	Ruh Brothers	53	2 in	Qal	Top of casing	+1.8	4,098.80	17.80	14.65	None		Cased 27 feet.
NE¼NW¼ sec. 25	School district 17	15	1½ in	Qal	Lower valve seat	+1.7	4,097.85	Dry	13.90	do		
SE¼SW¼ sec. 28	Unknown	18	2 in	Qal	Top of casing	+1.4	4,103	16.45	15.85	do		
Lot 3 sec. 35	J. E. Graves	21	4 in	Qal	Top of board	+.5	4,096.30	14.50	13.80	S	52	
T. 25 S., R. 32½ E.												
NE¼SE¼ sec. 1	Unknown	22	6 in	Qal	Top of casing	+.5	4,097	14.60	14.00	None		
NW¼SE¼ sec. 1	Will Howard	200±	2 in	Qal						S	52	
SE¼SW¼ sec. 1	C. M. Spencer	23	4 by 4 ft	Qal	Top of platform	+.2	4,103.10	23.45	20.55	None		No casing.
do	do	86	1½ in	Qal	Lower valve seat	+2.7	4,102.45	15.00	13.75	D		Reported 190 feet deep when drilled.
T. 25 S., R. 32½ E.												
NW¼SE¼ sec. 2	L. F. Seely	253	2 in	Qal(?)						D		Cased 180 feet.
SE¼SW¼ sec. 4	Unknown	51	8 in	Qal	Top of casing	+0.2	4,098.65	15.55	12.00	S		
do	do	15	6 by 6 ft	Qal	Top of curb	+.4	4,098.65	Dry	11.20	None		
Lot 3 sec. 5	Fred Timm	67	4 in	Qal	do	+.4	4,105.65	23.20	20.15	D		Originally drilled 185 feet deep. No casing.
do	do	22	8 in	Qal	Top of pump support.	+2.1	4,107.40	Dry	19.80	D	52	No casing.
Lot 3 sec. 6	Scott Catterson	18	4 ft	Qal	Top of cover	+2.0	4,106.60	18.98	18.00	D		Do.
NE¼SW¼ sec. 8	Unknown	14	4 in	Qal	Top of casing	+3.5	4,102.60	16.85	7.55	None	52	
NW¼NW¼ sec. 11	do	22	4 by 4 ft	Qal	Top of girder	.0	4,096.00	20.10	18.25	do		Do.
SW¼SE¼ sec. 15	J. A. Gard	14	7 ft	Qal	do	+.4	4,095	[8] 13.7	12.85	do		
SW¼SW¼ sec. 17	Unknown	13½	4 by 6 ft	Qal	do	+1.0	4,097.70	Dry	12.80	S		
SE¼NW¼ sec. 19	Oregon Oil Co	56	10 in	Qal	Top of timber	.0	4,096	15.75	14.60	None		Oil prospect, drilled 680 feet deep then abandoned. Casing pulled.
Lot 5 sec. 19	Charles Sparlock	23½	6 in	Qal	Top of casing	+.9	4,098.5	18.75	18.75	D	49	
Lot 1 sec. 20	J. C. Ansmus	19½	3 in	Qal	do	+2.3	4,098.30	Dry	18.15	D		Cased 18 feet.
do	do	47	4 in	Qal	Top of curb	+1.0	4,096.75	16.60	15.70	S	52	
Lot 7 sec. 22	Ralph Catterson	18	6 by 8 ft	Qal	Top of platform	+.9	4,097.70	18.65	[8] 10.95	None		
do	do	50	1½ in	Qal						S		
Lot 4 sec. 28	Unknown	12	1½ in	Qal	Lower valve seat	+2.2	4,097	14.30	13.70	None		
([illegible])	do	48	6 in	Qal	Top of 1-inch board	+.2	4,096	14.90	11.60	S		No casing.
([illegible])	B. C. Ansmus	56	6 in	Qal	Top of curb	.0	4,093	15.00	14.30	D		
([illegible])	Unknown	30	6 in	Qal	do	+.2	4,095	14.05	13.05	S		
Lot 6 sec. 30	do	13	1½ in	Qal	Lower valve seat	+1.8	4,097.25	13.65	13.65	None		
([illegible])	B. C. Ansmus	20	4 in	Qal	Top of casing	+.5	4,094.5	12.60	12.60	D		Do.

[Use of water—D, Domestic; Ind, industrial; Ir, irrigation; P, public service; R, railroad; S, stock]

Location	Owner	Depth (feet)	Diameter	Geologic horizon of water-bearing bed [1]	Measuring point: Description	Measuring point: Above or below land surface (feet)	Measuring point: Altitude above sea level (feet)	Observed extremes of ground-water stage, 1930 (feet below measuring point): Lowest	Observed extremes of ground-water stage, 1930 (feet below measuring point): Highest	Use	Temperature (°F.)	Remarks
T. 25 S., R. 33 E.												
Lot 4 sec. 5	Unknown	39	6 in	Qal	do	.0	4,113	19.85	19.50	D		
SE¼SW¼ sec. 6	do	21	5 by 5 ft	Qal	Top of girder	.0	4,101.85	18.07	13.55	D		Do.
SE¼SW¼ sec. 7	do	120	6 in	Th or Qal.	Top of platform	+.9	4,102.95	10.45	9.50	D		
NE¼SE¼ sec. 12	do	54	6 in	Qal	Top of casing	+1.3	4,118	17.60	17.60	D		
NW¼NW¼ sec. 23	do	28½	2 in	Qal	do	+2.0	4,110	26.15	26.85	D		
([13])	Hill Bros	75	6 in	Qal	Land surface	.0	4,093			S	52	Do.
NE¼NE¼ sec. 34	Geological Survey	14	3 in	Qal	Top of casing	.0	4,099	13.65	12.10	D		Do.
T. 25 S., R. 34 E.												
NE¼SW¼ sec. 7	Oregon Short Line R. R. Co.	415	10 in	Ts(?)			4,134			R		
T. 26 S., R. 28 E.												
NE¼SW¼ sec. 3	Unknown	9	8 by 8 ft	Qal	Top of girder	+1.3	4,131	8.25	8.25	None		
NW¼SW¼ sec. 12	William Hanley Co.	190+	3 in	Th(?)	Top of casing	+1.1	4,119	6.95	6.95	S		
NW¼NW¼ sec. 14	do	33	6 in	Qal	do	+.6	4,119	6.25	4.75	S	54	
T. 26 S., R. 29 E.												
NE¼SE¼ sec. 18	do	14	6 by 6 ft	Qal	Top of cover	+1.8	4,120	10.25	10.25	S		
NW¼SE¼ sec. 27	Unknown	130	5½ in	Th	Top of casing	+2.0	4,105	12.35	11.60	None	52	
SW¼SW¼ sec. 27	do	34	2 in	Qal	do	.0	4,107			S	54	Flows slight amount. Flowing when visited.
T. 26 S., R. 30 E. "North of Malheur Lake"												
Lot 4, sec. 28	Geological Survey	7½	3 in	Qal	do	+.5	4,086.05	4.83	4.83	None	55½	Cased 2.5 feet.
NE¼ sec. 29 (?)	Unknown	40	2 in	Qal	do	+2.2	4,102	11.90	11.60	do		
Lot 1, sec. 31	Geological Survey	6	3 in	Qal	do	+.2	4,085.05	4.57	4.37	do	60	Do.
T. 26 S., R. 31 E. "North of Malheur Lake" and T. 27 S., R. 30 E. "South of Malheur Lake"												
SE¼NW¼ sec. 1	J. S. Wilson	10	2 in	Qal	Top of pump support.	+.8	4,095.20	8.92	8.92	D		No casing.
NW¼SW¼ sec. 1	do	11	3 in	Qal	Land surface	.0	4,096.5	10.40	10.40	None		Do.
NE¼SW¼ sec. 1	do	71½	4 in	Qal	Top of casing	.0	4,100.10	13.93	12.90	do		Reported drilled 400 feet deep.
SE¼SE¼ sec. 5	Geological Survey	14	3½ in	Qal	do	+.4	4,095.48	13.10	11.90	do		Cased 2.5 feet.
NE¼NE¼ sec. 15	do	14	3 in	Qal	do	+.5	4,096.41	13.60	13.08	do		Do.
SE¼SE¼ sec. 15	do	17	3 in	Qal	do	+.5	4,100.75	16.80	16.61	do		Do.
SW¼NE¼ sec. 25	W. M. McKenzie	23	2 in	Qal	Lower valve seat	+1.3	4,099.30	13.80	13.80	do	52	
SE¼SE¼ sec. 25	Unknown	21	4 in	Qb (?)	do	+1.0	4,111.90	21.40	20.85	do		
Lot 1, sec. 28	L. L. Gridlen	14	4 in	Qal	Top of cover	.0	4,091.60	6.80	5.50	do		No casing.
Lot 2, sec. 32	Geological Survey	13	3 in	Qal	Top of casing	+5.	4,094.05	12.00	11.97	do	52	Cased 1.5 feet.
NW¼SW¼ sec. 35	Mrs. R. L. Thornton.	25	2 in	Qal	Lower valve seat	+2.0	4,096.05	10.00	9.95	S	52½	
do	do	53	1½ in	Qal	Top of casing	.0	4,095.35	5.60	5.30	D	54	Do.
T. 26 S., R. 32 E. "North of Malheur Lake" and T. 28 S., R. 31 E. "South of Malheur Lake"												
Lot 8, sec. 5	Pacific Live Stock Co.	1,430	6 in	Ts						S	106	Flowing when visited. Flow estimated 30 gallons a minute.
Lot 4, sec. 7	Unknown	18	4 by 6 ft	Qal	Top of curb	+0.3	4,095.60	11.50	10.60	None		
([13])	J. E. Graves	18		Qal	Top of casing	+1.5	4,091.35	12.00	10.30	S	51	Do.
([13])	do	60		Qal	([7])	+.2	4,095.00	12.15	5.80	S	50	No casing. Measuring point, copper washer on 4- by 4-inch platform.
([13])	Lynn Vickers	18	6 by 6 ft	Qal	Top of cover	.0	4,094.85	13.55	[4] 6.60	D	51	
([13])	— — Hoffman	54	1½ in	Qal	Lower valve seat	+3.5	4,097.25	11.95	11.95	S		
NE¼NE¼ sec. 18	W. Scott Haley	46	2 in	Qal	Lower valve seat	+2.0	4,099.55	14.65	13.90	D	51	Cased 40 feet.
do	do	21	4 in	Qal	Top of casing	+1.2	4,096.05	13.35	13.10	S	52	
([13])	Unknown	18½	6 by 6 ft	Qal	Lower valve seat	+2.6	4,097.80	16.00	7.47	D		
([13])	W. A. Campbell	18	6 in	Qal	Top of platform	+.5	4,095	14.10	[4] 3.35	D	50	No casing.
([13])	Unknown	15	4 by 6 ft	Qal	Top of 4- by 4-inch wood sill.	.0	4,092.5	10.35	10.35	S		
Lot 3, sec. 25	C. H. Marshall	59	1½ in	Qal	Lower valve seat	+2.4	4,097.5	9.20	9.20	D	51	
Lot 7, sec. 33	Pete Caldwell	14	10 in	Qal	([8])	+1.6	4,100	10.00	10.00	Ir		Irrigates garden. No casing. Measuring point, top of tee on pump discharge pipe.
Lot 1, sec. 33	do	14	10 in	Qal	Top of board	.0	4,098.4	9.40	5.35	None		No casing.

[Use of water—D, Domestic; Ind, industrial; Ir, irrigation; P, public service; R, railroad; S, stock]

Location	Owner	Depth (feet)	Diameter	Geologic horizon of water-bearing bed [1]	Measuring point: Description	Measuring point: Above or below land surface (feet)	Measuring point: Altitude above sea level (feet)	Observed extremes of ground-water stage, 1930 (feet below measuring point): Lowest	Observed extremes of ground-water stage, 1930 (feet below measuring point): Highest	Use	Temperature (°F.)	Remarks
Lot 6, sec. 34	W. J. Dunn	25½	4 in	Qal	Top of casing	+1.7	4,100	9.45	4.45	D		
Lot 4 (?) sec. 35	Alva Springer	16	5 by 5 ft	Qal	Top of cover	+.5	4,099.65	7.05	5.03	D		Do.
Lot 12, sec. 36	J. Kado	11	4 by 4 ft	Qal	Top of curb	+2.3	4,096	Dry	12.65	D		
T. 26 S., R. 32 E. "South of Malheur Lake"												
([13])	C. B. Ausmus	12	6 in	Qal	Top of pump base	.0	4,089.55	9.10	Flooded.	S		No casing.
([13])	Unknown	14½	8 in	Qal	Top of pipe union	.0	4,094.25	9.84	9.84	S	48	Do.
([13])	do	45	8 in	Qal	Bottom of cover	.0	4,093.95	9.57	9.57	S		Do.
([13])	Unknown	35	4 in	Qal	Top of casing	−1.8	4,091.25	.17	.05	S	56	
Lot 1, sec. 14	do	31	6 in	Qal	do	0.0	4,095	.67	.67	None		
Lot 2, sec. 14	Frank Lueder	33	2 in	Qal	Top of pump support.	.0	4,095.5	2.60	2.10	S		Cased 38 feet. Flows slight amount at times.
([13])	W. J. Dunn	46	6 in	Qal	Top of pump support.	+.8	4,095	7.00	1.00	S	51	Do.
Lot 3, sec. 23	Frank Lueder	12	1¼ in	Qal	Land surface	.0	4,101	6.±	6.±	S	51	
Lot 2, sec. 28	Mrs. Frank Dunn	80	3 in	Qbv						S	52	Flowing when visited. Flow estimated 20 gallons a minute.
Lot 1, sec. 31	T. T. Dunn	67	4 in	Qbv	Top of pump platform.	+1.5	4,112	19.40	16.30	S		
Lot 2, sec. 32	do	100	2 in	Qbv	Top of casing	.0	4,098	.15	.15	None		Originally flowed small amount.
Lot 6, sec. 33	Mrs. Frank Dunn	83½	6 in	Qbv	do	+.5	4,099	4.35	4.15	do		
NW¼SE¼ sec. 34	Hahn & Backus	215	8 in	Qbv						Ir	54	Flowing when visited. Flow estimated 120 gallons a minute.
do	do		8 in	Qbv						Ir	53½	Flowing when visited. Flow estimated 50 gallons a minute.
do	do	135	8 in	Qbv						Ir		Flowing when visited. Flow estimated 90 gallons a minute.
T. 26 S., R. 33 E.												
([13])	Hill Bros	70	6 in	Qal	Land surface	.0	4,093	7.90	7.90	S	52	No casing.
([13])	W. J. Dunn	20	10 by 20 ft	Qal	Top of platform	.0	4,093.35	9.03	7.25	S	50	
	A. Haasterich	201	2 in	Th (?)	Top of casing	−7.0	4,097.65	.85	.50	None		
	Unknown	157	4 in	Th (?)	do	.0	4,109.50	13.40	13.05	S		
Lot 3 sec. 17	R. J. Haines	15	6 in	Qal	Top of pump support.	+2.0	4,102.25	8.71	8.50	S	52	Do.
Lot 13 sec. 22	Geological Survey	11	3 in	Qal	Top of casing	.0	4,096.85	9.45	8.60	None	50	Do.
SE¼SW¼ sec. 26	Unknown	35	8 in	Qal	Top of cover	+.2	4,103.40	12.30	11.95	S	54	Do.
NE¼NE¼ sec. 27	Geological Survey	16	3 in	Qal	Top of casing	+.3	4,100.05	13.85	13.35	None	51	Cased 2.5 feet.
T. 27 S., R. 29 E.												
SW¼SW¼ sec. 3	A. W. Hulburt	48	2 in	Qal	Land surface	.0	4,101			Ir	53	Irrigates lawn. Flowing when visited. Flows about 10 gallons a minute. Cased 48 feet.
Lot 4 sec. 5	Lewis M. Hughet	47	2 in	Qal	Top of casing	+2.0	4,117			D	68	Flowing when visited. Flows 2 gallons a minute. Cased 20 feet.
SW¼NW¼ sec. 5	do	8½	1½ in	Qal	Lower valve seat	+3.4	4,133	10.25	10.25	None		Cased 8 feet.
SW¼SE¼ sec. 5	Mrs. I. N. Hughet	63	6 in	Qal	Land surface	.0	4,115			Ir	64	Flowing when visited. Flows about 100 gallons a minute. No casing.
NE¼NW¼ sec. 9	Mrs. M. I. Hughet	43	2 in	Qal	do	.0	4,108			D	60	Cased 40 feet. Flowing when visited. Static water level 6± feet above land surface.
NE¼NW¼ sec. 10	P. G. Smith	40	1½ in	Qal	do	.0	4,098			D	52	Flowing when visited. Flows ¼ gallon a minute.
NE¼NW¼ sec. 15	Edith Sizemore	103	2 in	Td (?)	Land surface	.0	4,120			D	64½	Flowing when visited. Flows about ½ gallon a minute. Static water level 2± feet above land surface.
SE¼SE¼ sec. 15	Unknown	18	6 ft	Qal	Top of cover	.0	4,120	15.75	15.75	None		No casing.
T. 27 S., R. 30 E.												
Lot 2 sec. 1	W. L. Newton	54	5 ft	Qal	Top of platform	.0	4,030	39.00	39.90	D		No casing.
NW¼SW¼ sec. 2	State of Oregon	43½	6 in	Qal	Top of casing	+.5	4,132.50	42.15	41.60	None		

SW¼SW¼ sec. 3	Unknown	55	6 in	Qal	do	+.8	4,130.20	45.00	42.75	do		
Lot 2 sec. 4	Geological Survey	17	3 in	Qal	do	+.5	4,098.75	17.65	16.90	do		Cased 1.5 feet.
Lot 4 sec. 4	W. J. Dunn	315	1¼ in	Td	do	+2.0	4,094.40			S	65½	Flowing when visited. Flow estimated 35 gallons a minute.
Lot 7 sec. 8	Geological Survey	13	3 in	Qal	do	+.5	4,093.55	11.81	11.45	None	54	Cased 1.5 feet.
(15)	do	6	3 in	Qal	do	+.5	4,085.70	5.60	4.85	do	54	Do.
T. 27 S., R. 31 E.												
SW¼NW¼ sec. 3	Sodhouse ranch	21		Qal	(2)	.0	4,100	7.30	7.05	S		Measuring point, top of 2- by 4-inch timber over casing.
Lot 1 sec. 5	Unknown	18	1½ in	Qal	Lower valve seat	+1.8	4,104	14.05	6.80	None	51	
T. 27 S., R. 32 E.												
SE¼NW¼ sec. 4	T. T. Dunn	70	6 in	Qbv	Land surface	.0	4,095			S	52	Flowing when visited. Flows about 40 gallons a minute. Cased 45 feet.
Lot 6 sec. 4	do	130	6 in	Qbv	do	.0	4,095			S	52	Flowing when visited. Flows about 50 gallons a minute.
SE¼NE¼ sec. 5	do	100+	4 in	Qbv	do	.0	4,096			S	54	Flowing when visited. Flows about 3 gallons a minute.

1 Qal, valley fill; Qb, late basalt (Qbh, near Hines; Qbv, near Voltage); Th, Harney formation; Td, Danforth formation; Ts, Steens basalt.
2 See remarks.
3 Creek or river channel flowing close by.
4 For periodic measurements of depth to water see pp. 152–180.
5 Windmill operating slowly in well during measurement.
6 For chemical analysis of water see pp. 114–118.
7 Reported by owner.
8 Water standing in creek or river channel close by.
9 Well dry at depth indicated.
10 Water flowing in ditch close by.
11 Water level drawn down by adjacent irrigation well.
12 Pump operating in well during measurement.
13 Water level depressed by steady pumping.
14 Windmill at observation well stopped just before measurement.
15 Unsurveyed land within inner meander line of Malheur and Harney Lakes.

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APPENDIX II

Records of Selected Wells in the Harney Valley Area (From Leonard, 1970)

Appendix II. Records of selected wells in the Harney Valley area. (From Leonard, 1970)

Type of well: B, bored; Dg, dug; Dr, drilled.
Finish: F, gravel packed and perforated; G, gravel packed and screened; Ø, open end; P, perforated; S, screened; X, open hole.
Altitude: Altitude of land surface at well, in feet above mean sea level.
Water level: Depth to water given in feet and decimal fractions were measured, those given in whole feet were reported by well driller or owner. F, flowing well whose static water level is not known.
Specific conductance: Field measurements by U.S. Geological Survey personnel or county agent.

Type of pump: C, centrifugal; N, none; P, piston; S, submersible; T, turbine.
Well performance: Yield, in gallons per minute, and drawdown, in feet, generally reported by driller, owner, or pump company for period indicated under "Remarks."
Use: H, domestic; I, irrigation; N, industrial; P, public supply; S, stock; T, institutional; U, unused.
Remarks: C, chemical analysis reported in table 6; L, driller's log available in Survey files; P, pumped; B, bailed for indicated time to determine yield under "Well performance"; Obs, observation well whose water level is measured periodically.

Section Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
								T. 22 S., R. 30 E.									
27ddc	W. W. Arntz	Dr	1961	127	12	40	X	Gravel, cinders	4,230	52.42	10-14-68	140	T, 50	700	--	I	L, Obs. C.
35bbb	do	Dr	1966	97.5	12	20	X	Sandstone, pumice	4,190	37.26	10-16-68	--	N	100	--	N	B 2 hr, L.
								T. 22 S., R. 31 E.									
25aba	Les Tyler	Dr	1931	490	16	--	--	Tuff, "shale"	4,180	24.15	5-12-32	--	T, 40	--	--	I	
28dda	Harry Pon	Dr	1961	490	12	22	X	Lava, gravel	4,170	26.16	12-12-68	--	T, --	1,000	42	I	P 4 hr, L, Obs.
32bbb	do	Dr	--	200	14	100	--	--	4,190	14.48	10-11-68	--	T, 30	240	95	I	
32bcc	do	Dr	1961	260	14	36	P, X	--	4,180	8	2-14-61	--	T, --	540	122	I	P 8 hr, L.
33baa	do	Dr	1962	425	12	21	X	Sand and gravel, "rock"	4,190	44.70	10-11-68	--	T, 30	1,100	86	I	Do.
33ccd	do	Dr	1961	390	12	80	X	Gravel, pumice, cinders	4,155	16.15	10-16-68	250	T, 30	900	44	I	P 4 hr, L.
34aaa	George Purdy	Dr	1966	725	12	40	P, X	Gravel, cinders	4,162	19.26	9-10-68	240	T, 40	600	122	I	P 24 hr, L, C.
34ccb	L. F. Lazarus	Dr	1930	288	18	68	X	Gravel, sand, rock	4,153	15.73	12-12-68	--	--	400	50	S, I	Obs.
36aba	R. F. Smith	--	--	240+	12	--	--	--	4,158	14.8	10-23-69	--	T, 20	--	--	I	
36bab	do	Dr	1961	335	12	18	P, X	Gravel, sand, lava	4,156	16.04	12-12-68	--	T, 25	500	98	I	P 4 hr, L, Obs.
36cad	do	--	--	360	40	12	X	--	4,150	4.56	5-24-69	--	T, 10	300	150	I	
								T. 22 S., R. 32 E.									
34aaa1	Desert Growers, Inc.	Dr	--	1,000	6	120	X	--	4,148	F	9-13-68	670	C, 2	20-30	--	I	C; used to heat greenhouse for winter vegetables.

-Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
								T. 22 S., R. 32 E.--Continued									
34aaa2	Desert Growers, Inc.	Dr	1965	215	6	60	X	Gravel	4,148	--	--	245	S	35	7	H,I	
35bbb	R. W. Davis	Dr	1957	880	24	90	X	Gravel, sand	4,150	4.68	9-13-68	600	T, 50	--	--	I	L; 160°F water, cooled in reservoir to use for irrigation.
36bbb	William Huggard	Dr	1967	611	12	60	X	Sand, clay, sandstone, rock, pumice	4,142	11.54	10-11-68	--	N	110	51	I	P 4 hr, L.
								T. 22 S., R. 32½ E.									
5bb	Charles Danuser	Dr	1966	545	6	30	X	Basalt, gravel	4,395	2	11- 6-66	--	N	2	100	N	P ½ hr, L.
18aad	do	Dr	1967	445	6	20	X	Basalt, sand	4,300	26.09	10-10-68	--	N	110	80	I	P 4 hr, L.
30cdb	Jack McGee	Dr	1964	647	12	--	X	Sand, rock, gravel	4,146	11.23	do	290	S	450	166	I	P 1 hr, L, C.
36aab	Richard Temple	Dr	1968	182	12	20	X	Clay, rock	4,135	13.63	do	360	T, 15	495	94	I	P 6 hr, L, C.
36aac	J. C. Temple & Sons	Dr	1964	132	12	52	X	Lava, pumice	4,133	11.90	do	360	T, 40	560	91	I	P 6 hr, L.
36dab	do	Dr	1966	345	12	71	X	Shale, gravel	4,132	9.89	10-14-68	--	T, 15	341	51	I	Do.
36ddb	do	Dr	1966	840	12	80	X	Shale, pumice	4,132	7.56	do	--	N	100	95	I	P 5 hr, L.
								T. 22 S., R. 33 E.									
27adc	John Temple	--	--	833	--	--	--	--	4,170	29.25	10-14-68	270	T, 10	--	--	I	Obs.
27cbd	do	Dr	--	100+	6	--	Ø, F	--	4,165	35.25	do	--	P,wind	5-10	--	S	
31aaa	Donald Corcoran	Dr	1961	225	6	143	X	"Blue granite"	4,138	13	10-18-61	--	P,wind	25	20	S	B 2 hr, L.
34bbb	do	Dr	1961	167	6	160	Ø, X	Broken "granite"	4,153	21.40	10-14-68	--	P,wind	20	18	S	Do.
								T. 23 S., R. 30 E.									
12dab1	City of Burns	Dr	1925	253	12	150	X	Welded tuff, breccia	4,229	85	12-10-58	--	T, 50	800	27	P	P 4 hr.
12dab2	do	Dr	1926	251	12	150	X, S	do	4,229	85	do	--	T, 50	800	27	P	Do.
12ddd	do	Dr	1950	304	16	144	X	Welded tuff, lava	4,160	14	12-10-59	--	T, 100	1,280	81	P	P 2 hr, L.
14dcc	F. B. Carland	Dr	1967	305	14	140	X	Volcanic rock, cinders	4,250	105.15	10-16-68	160	T, 30	1,000	105	I	P 7 hr, L.

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Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
								T. 23 S., R. 30 E.--Continued									
20cac	U.S. Air Force	Dr	1959	1,224	10	1,122	X, P	Lava, cinders	5,233	1,090	1-17-59	--	S, 30	68	23	T	P 12 hr, L.
23bdd	City of Hines	Dr	1930	325	10	275	X	--	4,315	--	--	--	T	800	--	P	
23cda	do	Dr	1967	345	14	260	X, P	Volcanic rock, cinders	4,200	65	4-28-67	295	T, 200	675	150	P	P 8 hr, L.
23dad	do	Dr	1949	400	12	100	X	--	4,157	--	--	220	T, 100	800	--	P	
24aad	Harney County Fair Assoc.	Dr	1963	218	10	195	X	Sandstone, sand	4,143	6.39	10-11-68	140	T, 15	130	70	I,H	P 6 hr, L.
24bba	J. E. Enneberg	Dr	1967	210	6	60	X, P	--	4,163	24.20	5-27-69	--	S, 3	40	20	I	B 2 hr, L.
26add	Hines Lumber Co.	Dr	--	190	--	--	--	--	4,139	--	--	--	C, 75	--	--	--	Flowed, when drilled.
26dac	do	Dr	1965	218	12	20	X, P	Cinders, volcanic rock, sand and gravel	4,147	10	4- 7-65	220	T, 100	1,500	23	N	P 8 hr, L.
35aad	do	Dr	1965	200	12	56	X, P	Cinders, volcanic rock	4,140	5	3-27-65	220	T, 125	1,750	1.5	N	P 8 hr, L, C.
36bbc	Walter Baker	--	--	--	12	--	--	--	4,137	4.82	10- 3-69	--	--	1,100	--	I	Flowed, when drilled.
36cbb	Hazel M. Gouldin	Dr	1965	198	10	104	X	Red and black lava	4,138	.25	5-27-69	190	J, 2	--	--	I	L; originally flowed 400 gpm.
								T. 23 S., R. 31 E.									
3bbb	Harney County	Dg	1935	14	18	14	P	"Quicksand"	4,153	--	10- -68	--	N	--	--	N	Obs; 1½-inch pipe inside wooden crib.
3ada	Tommy Swisher	--	--	150	--	--	--	--	4,145	9.30	10- 8-68	320	T, 10	700	30	I	
4abc	Lester Tyler	Dr	1929	98	18	38	X, P	Sand, rock	4,153	13.12	9-10-68	400	T, 30	700	--	I	L.
4bca	do	Dr	1961	200	12	85	X, P	Cinders, rock, gravel	4,156	15.6	do	--	T, 30	1,100	61	I	
5aac	Harry Pon	Dr	1961	400	12	18	X, P	Gravel, volcanic rock	4,157	20.35	do	240	T, 40	1,000	22	I	P 4 hr, L, Obs, C.
5aad	do	Dr	1961	438	14	60	X, P	Gravel, rock	4,155	15.20	do	--	T, 40	1,000	44	I	P 4 hr, L.
5bca	Eban Ray	Dr	1962	214	12	120	X, P	Gravel, sand	4,162	--	10- -68	250	T	950	60	I	L, Obs.
5cba	Harry Pon	Dr	1961	205	14	14	X, P	do	4,155	10.10	9-10-68	320	T, 20	700	59	I	P 41 hr, L.
5cbb	Eban Ray	Dr	1961	200	12	15	X, P	do	4,160	13.93	10- 9-68	--	T, 20	700	55	I	P 28 hr, L.
6add	Lloyd Hill	Dr	1965	185	8	76	X, P	Gravel	4,160	14.10	do	--	S, 7½	100	20	I	B 1 hr, L.

Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Draw-down (feet)	Use	Remarks
								T. 23 S., R. 31 E.--Continued									
6bcb	Kenneth Retherford	Dr	1969	170	6	161	X	Sand and gravel	4,161	19.55	5-20-69	255	T, ?	350	10	I	P 15 hr, L; drilled to 150 feet in 1968.
6bcc	Hobart Tiller	Dr	1966	120	12	55	P	Gravel	4,160	14.77	10- 9-68	250	T, 15	200	33	I	P 3 hr, L.
6ccd	Pluribus Tiller	Dr	1968	140	8	110	P	Gravel and sand	4,160	17	4-26-68	--	--	200	55	I	P 4 hr, L.
9dbb	Hilton Whiting	Dr	1961	364	12	55	X, P	Gravel, sand, cinders	4,146	8.74	9-10-68	280	T, 50	1,100	65	I	P 22 hr, L.
11bbb	Cliff Gunderson	Dr	1966	170	6	107	X	Coarse sandstone	4,143	15	10- 1-66	180	S, ?	150	5	H	B 2 hr, L.
11dcc1	Riley & Sewell	Dr	--	120	12	15	Ø, P	Gravel	4,145	11.34	10- 8-68	--	N	--	--	N	L, Obs.
11dcc2	do	Dr	1959	561	12	220	X	Pumice, boulders	4,145	18.13	do	--	T, 30	--	--	I	Do.
12ccd	Burns Airport	--	--	76	5	--	--	--	4,140	16.20	10- 9-68	--	S, ?	--	--	H	
13bcc	Clarence Gardner	B	1935	330	12	83	--	Sand, gravel, clay	4,143	15.22	do	490	T, 30	--	--	I	L.
14aab	Harney County	Dg	1936	17	18	17	P	Sand	4,143	10.32	12-11-68	--	N	--	--	N	Obs.
15abb	Henry Ausmus	Dr	1930	60	12	43	F	Gravel	4,145	9.55	9-10-68	--	T, 15	600	50	I	P 2 hr, L.
16bcc	Harney County	Dg	1936	13	18	14	P	Sand	4,146	8.78	12-11-68	--	N	--	--	N	Obs.
16dbb	T. A. Jones	Dr	1930	300	12	37	P	Sand and gravel	4,146	10.28	11-21-68	--	T, ?	750	26	I	Obs, L.
19daa	Dorman Otley	Dr	1955	113	12	18	X, F	Gravel	4,142	8.09	10-11-68	200	T, 30	1,450	40	I	P 7 hr, L.
20abd	Culp Cattle Ranch	Dr	1963	43	6	33	P	do	4,140	8.50	10- 9-68	--	S, ?	50	10	S	P 24 hr, L.
24aac	Al and Ron Brown	Dr	1962?	114	12	20	F	--	4,137	18.55	10- 8-68	280	T, 20	660	79	I	P 24 hr, C.
28bbb	Culp Cattle Ranch	Dr	1930	45	8	--	--	Sand and gravel	4,138	9.4	10- 9-68	--	N	--	--	N	
33cbc	Harney County	Dg	1935	12.6	18	13	P	Coarse sand	4,134	7.95	10-22-68	--	N	--	--	N	Obs.
								T. 23 S., R. 32 E.									
2bca	Dennis Dooley	Dr	1969	225	16	--	G	Gravel	4,135	12.73	5-24-69	--	--	500	170	I	
3aaa	do	Dr	--	90	--	--	--	--	4,135	11	?	295	T, 20	330	18	I	P 16 hr.
3aad	do	Dr	1963	220	12	220	--	--	4,135	11.13	10- 9-68	--	T, 20	240	--	I	Obs.
7bdc	Dorland Ray	--	--	210	12	157	X	Gravel?	4,136	16.13	do	--	T, 10	--	--	I	
7cab	do	--	1926	93	18	36	Ø, G	Gravel, sand	4,135	13.43	do	245	T, 20	540	55	I	P 20 days, L, Obs, C.

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.--Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
								T. 23 S., R. 32 E.--Continued									
7dcb1	Dorland Ray	Dr	1916?	160	8	--	--	--	4,136	18.80	10-10-69	260	S	320	110	I	Pump test, October 1969.
7dcb2	do	Dr	1966	235	12	200	X	Pumice	4,136	19.22	10-11-69	--	N	--	--	N	L.
9cbd	Peter Clemens	Dr	--	36	6	--	--	--	4,132	13.90	10- 9-68	--	P,wind	--	--	S	
11bbc	J. H. Raine	Dr	1964	90	12	47	F	Sand, gravel	4,128	11.84	do	--	T, 15	580	29	I	P 30 hr, L.
12daa	Unknown	Dr	--	--	6	--	--	--	4,125	10.24	do	--	N	--	--	N	
13bbb	Pat Hays	Dr	1963	232	14	72	F	Gravel	4,125	9.95	do	380	T, 50	1,100	--	I	L.
18bbb	Bar Negative Ranch	Dr	1963	170?	16	160	X	--	4,140	28.21	10- 8-68	260	T, 75	1,800	60	I	P 36 hr, L; sulfur odor; originally drilled to 1,316 feet.
18ccb	do	Dr	1961	200	12	--	--	--	4,139	19.82	do	300	N	--	--	N	Cased to 96 feet now.
20cca	Henry Cowing	Dr	1968	155	6	153	X	Sand, gravel, black	4,134	19.04	10-10-68	--	S, ?	20	20	S	B 3 hr, L.
21bba	Bar Negative Ranch	Dr	1955	130	12	--	--	--	4,133	23.00	10- 8-68	--	T, 20	250	--	I	"Tiller well."
21cbc	do	Dr	--	--	12	--	--	--	4,133	26.46	do	--	T, ?	--	--	I	Pump removed in 1968.
22ccd	Wallace Shepard	Dr	1955	250	8	50	X, P	Sand, "shale"	4,128	29.78	10-10-68	--	T, 15	600	50	I	P 20 hr, L.
27bbb	Wayne Howes	B	1956	100	12	60	X	Sand and gravel	4,130	20.79	5-25-69	--	--	500	25	H,S	P 1 hr, L.
27bdb	do	Dr	1955	465	18	60	X	do	4,128	28.04	10-10-68	800	T, 30	500	25	I	P, L.
27cbd	do	--	1965?	330	8	100	X	do	4,128	--	--	--	T, ?	1,000	--	I	Not in use, 1968.
28aba	Bar Negative Ranch	Dr	1955	140	10	50	P, X	Gravel	4,131	32.98	10- 8-68	--	T, 25	--	--	I	L, Obs.
28acd	do	Dr	1959	250	14	50	P	do	4,129	31.72	do	725	T, 30	900	--	I	L, C.
28bbd	Roy Duhaime	Dr	1955	220	8	115	X, P	Sand and gravel	4,133	--	--	--	T, 7½	150	50	I	P 100 hr, L.
28bcc	do	Dr	1955	191	8	50	X, P	--	4,132	30.25	9-12-68	--	T, 25	590	50	I	Do.
29adb	do	Dr	1955	240	12	50	X, P	Sand and gravel	4,132	25.92	10- 8-63	--	N	1,150	57	N	P 17 hr, L, Obs.
29bbd	Wallace Shepard	Dr	1962	200	8	65	F	Sand, shale	4,132	20.70	8-15-67	580	T, 30	730	70	I	P 10 hr, L.
29daa	Roy Duhaime	--	--	--	--	--			4,130	--	--	550	P, 1½	--	--	S	
30ddd	Harney County	Dg	1936	19.3	1¼	19	P	Sand	4,131	6.88	5-22-69	--	N	--	--	N	Obs, L.
31bbc	Sitz & Sitz	Dr	1962	240	12	90	X	Sandstone	4,130	13.37	10-13-68	--	N	50	40	N	B 1 hr, L.

--Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
T. 23 S., R. 32 E.--Continued																	
32aaa	Roy Duhaime	Dr	1963	224	12	90	P	Gravel	4,123	24.43	10- 8-68	--	T, 50	1,000	100	N	P 10 hr, L.
T. 23 S., R. 32½ E.																	
1bbb	E. A. McConville	Dr	--	350	24	--	F	--	4,130	11.57	10-10-68	300	T, 15	450	63	I	Obs.
1bdc	do	Dr	1968	115	12	20	F	Clay and gravel	4,133	10.20	do	--	T, 15	350	15	I	L.
1cdc	Meadowland Ranches	Dr	--	110?	6	--	--	--	4,130	10.50	10-14-68	--	N	--	--	N	
9ccc	do	Dr	--	180?	6	--	--	--	4,125	10.48	10-10-68	--	S, ?	--	--	S	Not in use.
10cdc	Mrs. Wesley Claunch	Dr	1966	205	12	40	X	Sand, rock	4,125	7.59	do	--	N	1,118	33	N	P 3 hr, L.
14adb	Unknown	Dr	--	104?	6	--	--	--	4,125	9.37	do	--	S	--	--	S	Not in use.
19baa	do	Dr	--	180	6	--	--	--	4,125	12.10	10- 9-68	--	S	--	--	S	Do.
23dab	do	Dr	--	64?	6	--	--	--	4,123	9.57	10-10-68	--	S	--	--	S	Do.
26cbb	Harry Withers	Dr	1964	253	6	161	X	Black sandstone, gravel	4,116	2.82	do	--	S	60	1	S	B 2 hr, L.
32dbc	Unknown	Dr	--	314	6	--	--	--	4,120	8.68	do	--	S	--	--	S	
T. 23 S., R. 33 E.																	
5bca	A. J. Lawson	Dr	1964	99	12	48	F	Clay and gravel	4,133	8.64	10-10-68	--	C	100	5	I	B 2 hr, L.
8aac	Jesse Hankins	Dr	1969	365	12	30	F, X	Gravel and sand	4,133	--	--	--	--	--	--	--	L; not yet in use.
10abb	Lyle Vickers	--	--	--	2	--	--	--	4,137	3.48	5-22-69	--	P, 3	--	--	S	
12adb	do	Dr	1966	160	6	18	X	Pumice, gravel, basalt	--	22.00	7-26-66	--	S, 1	40	1	H	P 2 hr, L.
12dab	do	Dr	--	80	6	--	--	--	4,149	14.95	10-14-68	--	S	--	--	S	
15ccc	do	Dr	1965	101	6	101	Ø	Gravel	4,126	8.24	10-12-68	--	S, ?	15	4	S	B 3 hr, L.
18caa	Melvin Davenport	Dr	1967	100	8	60	P	"Clay"	4,128	6.73	5-21-69	--	S, 15	215	39	I	L.
20adb	Roy Ralston	Dr	1965	187	12	147	F	Sand	4,127	11.13	10-12-68	--	T, 50	1,270	--	I	L.
20ddc	Unknown	Dr	--	121	6	--	--	--	4,126	9.30	do	--	N	--	--	N	
29ccd	do	Dr	--	300?	6	--	--	--	4,126	10.14	do	--	S, ?	--	--	S	
31aba	do	Dr	--	300?	6	--	--	--	4,122	10.12	do	--	S, ?	--	--	S	

--Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
T. 23 S., R. 33 E.--Continued																	
33bcc	Unknown	B	1968?	49	6	--	X	--	4,123	8.27	10-12-68	--	N	--	--	H	Not completed.
33cdd	do	Dr	--	--	4	--	--	--	4,121	10.50	do	--	N	--	--	N	
36dda	A. A. McCrea	Dr	1965	150	6	125	X	Sandstone, gravel	4,134	9.20	8-16-67	--	S, 3/4	30	24	H	B 2 hr, L.
T. 23 S., R. 34 E.																	
7cac	Lyle Vickers	Dr	1969	615	12	140	X, P	Gravel, basalt	4,146	F	9-30-69	198	T, 25	350	100	I	P 5 hr, L.
7dbb	C. P. Topliff	Dr	1968	170	8	147	X	Lava, pumice	--	F	7-26-68	--	--	50	50	H	B 2 hr, L.
18aaa	J. W. Casey	Dr	1964	130	6	70	Ø	Cemented gravel, pumice	4,156	15.70	10-14-68	--	P, ¼	15	40	H	B 1 hr, L.
18acd	Dick Arnold	Dr	1963	77	12	19	F	Clay and gravel	4,143	17.55	do	--	T, 20	380	50	I	P 8 hr, L.
31add	Miller Bros.	Dr	1949	207	14	88	F	Sand and gravel	4,155	23.30	do	230	T, 10	350	120	I	L.
32aca	do	Dr	1961	328	12	77	X	Lava, cinders, sandstone	--	F	3-31-61	--	T, 7½	225	80	I	P 24 hr, L.
T. 24 S., R. 29 E.																	
2cab	Hal McUne	Dr	1966	150	12	110	P	Cinders, sand, gravel	4,198	47.58	10-10-68	--	N	100	45	I	B 1 hr, L.
T. 24 S., R. 30 E.																	
1abd	O. D. Hotchkiss	Dr	1930	564	10	117	X	Sandstone, volcanic rock	4,134	F	9- 8-64	160	N	600	--	I	L; deepened in 1964 from 472 feet; C.
2aac	Unknown	Dr	--	--	8	--	--	--	4,140	F	8-23-67	--	N	10	--	I	
7cdd	A. J. Kisle	Dr	1962	347	14	100	P	Cinders, lava	4,155	19.15	9-11-68	160	T, 40	1,800	84	I	P 3 hr, L.
8bdd	do	Dr	1966	300	12	110	X	Pumice, lava	4,148	14.39	do	--	T, 40	500	88	I	Do.
11aba	L. E. Tyler	Dr	1962	513	6	181	X	Pumice, cinders, sand	4,134	F	10-11-68	--	N	450	--	I	L.
11abd	do	Dr	1962	566	12	183	X	"Rock," cinders	4,133	F	do	160	N	2,000	--	I	L.
17bab1	A. J. Kisle	Dr	1967	300	12	70	X	Sand, gravel, cinders	4,148	10.0	9-11-68	--	N	100	7	I	B ½ hr, L.
17bab2	do	Dr	1967	324	12	100	P, X	Clay and gravel, sand and gravel	4,148	9.83	do	--	T, 60	1,050	61	I	P 4 hr, L.

Records of selected wells in the Harney Valley area--Continued

Section / Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
T. 24 S., R. 30 E.--Continued																	
17bbb	Adolf Kisle	Dr	1966	220	12	60	X	Clay and gravel, pumice, lava	4,150	14.58	9-10-68	150	T, 50	1,200	60	I	P 3 hr, L.
18acb	do	Dr	1966	240	12	40	X	Pumice, cinders, lava	4,153	16.42	9-11-68	--	T, 60	117	46	I	Do.
24acd	John Campbell & Son	Dr	1959	503	16	65	P, X	Sand, gravel, cinders	4,131	4.43	10-11-68	170	T, 30	3,200	85	I	P 4 hr, L.
26ddc	do	Dr	1959	501	16	90	P, X	Pumice, sand, gravel	4,130	49.68	do	380	T, 50	2,500	16	I	P 4 hr, L, Obs.
T. 24 S., R. 31 E.																	
1abc	Dan Oney	Dr	--	--	6	--	--	--	4,129	23.11	10-13-68	--	--	--	--	S	
5acb	State of Oregon	Dr	1967	245	12	25	F, S	Sand and gravel	4,130	6.49	10-11-68	200	T, 40	500	61	I	P 13 hr, L.
5dbb	do	Dr	1958	146	10	52	P	Gravel	4,129	5.02	do	160	N	475	45	N	P 4 hr, L.
28bcc	Harney County	Dg	1936	19	1½	15	--	do	4,126	9.63	10- 9-68	--	N	--	--	N	Obs.
T. 24 S., R. 32 E.																	
1ada	H. C. Vogler, Jr	Dr	--	631	6	--	--	--	4,125	17.06	10- 9-68	--	N	--	--	N	
4bbb	T. F. Drumm	Dr	1966	500	12	175	X	Clay	4,125	16.04	9-12-68	--	N	--	--	N	L.
5aad	John Wood	Dr	1965	270	12	213	X	Clay and sand	4,125	21.00	do	684	T, 15	--	--	I	L, C.
8dab	Harney Valley Devel. Co.	Dr	1937	2,812	8	--	--	--	4,120	F	do	580	--	35	--	N	Oil-test well, C.
12cbb	Mervin Johnson	Dr	1965	82	6	60	X	Sandstone	4,119	22.49	10- 9-68	--	J	10	--	H	B 1 hr, L.
T. 24 S., R. 32½ E.																	
13acb	C. W. Tripp	Dr	1967	242	12	230	X	Gravel	4,112	F	6-29-68	1,170	T	1,125	40	I	P 4 hr, L, C.
18bdc	Calvin Pelroy	Dr	1959	180	6	--	--	--	4,119	18.36	10- 9-68	--	S, 3/4	20	--	H	
20aac	Unknown	Dr	--	--	6	--	--	--	4,116	39.0	6-11-69	1,300	S	--	--	S	
22bcc	James Seeley	Dr	--	--	6	--	--	--	4,117	45.58	5-27-69	1,040	S	--	--	S	C; pumping measurement reported.
30add	Sam Gunterson	Dr	1967	185	6	99	X	Clay	4,106	15.95	10-13-68	3,200	S	45	54	S	B 2 hr, L, C.
30ddc	Ansel Marshall	Dr	--	130+	18	80	--	Sand, gravel	4,106	25.67	8-22-68	--	N	--	--	N	Obs, L.

Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Specific conductance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
								T. 24 S., R. 33 E.									
1cda	Diversified Ranches, Inc.	Dr	1964	357	14	100	F	Cinders, gravel	4,128	9.12	10-12-68	--	T, 50	1,000	100	I	P 10 hr, L.
1ddd	do	Dr	1963	185	6	171	X	Cemented cinders	4,132	12.32	10-18-68	--	N	30	9	N	B 3 hr, L.
2bdc	Joe Ingly	Dr	1967	250	6	229	X	Pumice	4,125	6	8-20-67	1,000	S	30	2	H	P 7 hr, L.
4abd	Diversified Ranches, Inc.	Dr	1964	380	14	100	F	Cinders, rock, gravel	4,122	8.10	10-12-68	--	N	760	100	N	P 10 hr, L.
6daa	George Mefford	Dr	1959	1,513	10	--	--	--	4,120	1.95	do	--	P	--	--	N	Oil test, started in 1939.
9acc	Dewey Kiem	Dr	1965	262	12	18	F	Clay and sand	4,118	5.05	do	--	N	600	55	N	P 6 hr, L.
9dad	H. C. Vogler, Jr.	Dr	--	400±	6	--	--	--	4,118	2.89	do	--	N	--	--	U	Unused stock well.
11ccc	do	Dr	--	180±	6	--	--	--	4,124	12.57	do	--	N	--	--	U	Do.
18bca	J. W. Coldiron	Dr	--	--	6	--	--	--	4,110	F	7- 2-68	1,200	S, 2½	20	--	H,S	Sulfur odor; tastes bad.
20aaa	David Long	Dr	1968	104	6	36	X	Clay and sand	4,110	6.59	10-12-68	--	N	40	--	U	B 1 hr, L.
24aac	R. H. Straw	Dr	1966	340	12	100	X	Lava, pumice, sandstone	4,128	11.97	10-15-68	4,000	T, 60	500	95	I	P 6 hr, L, C.
33ccb	Pacific Northwest Bell Telephone Co.	Dr	1966	200	6	126	X	Clay	4,110	26	7- 6-66	--	S	10	50	--	B 1 hr, L.
								T. 24 S., R. 34 E.									
6aac	Miller Bros.	Dr	1963	70	12	20	F	Gravel, sand, clay	4,145	25.00	10-14-68	--	T, 30	764	35	I	P 20 hr, L.
6abc	do	Dr	1968	85	12	20	F	Sand and clay	4,138	19.40	do	--	T, 30	650	56	I	P 12 hr, L.
19cdc	Jim Voss	Dr	--	800±	24	--	--	--	4,140	25.60	9-12-68	--	N	--	--	U	
31acb	J. W. Rossberg	Dr	1959	503	14	16	X	Pumice, basalt, cinders	4,142	32.32	10-15-68	--	T	225	58	I	P 60 hr, L.
31ada	do	Dr	1892	92	4	20	X	--	4,240	F	8-17-67	--	N	15	--	I	
31bac	do	Dr	1962	91	14	50	F	Gravel	4,137	26.39	10-15-68	600	T, 40	600	26	I	P 8 hr, C, Obs.
31cbd	do	Dr	1962	110	12	50	F	Gravel and sand	4,136	27.32	do	--	T, 30	600	80	I	P 5 hr, L.
31dcb	do	Dr	1960	305	14	9	X	Lava, cinders	4,145	35.72	8-24-67	--	N	200	100	U	P 2 hr, L.
31dda	do	--	1968	305	32	68	X	Gravel, cinders, lava	4,172	19.40	8-17-67	315	T	650	60	I	P 24 hr, L; originally 123 feet in 1956; C.

Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year com- pleted	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Alti- tude (feet)	Water level: Feet below datum	Water level: Date	Specific conduct- ance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Draw- down (feet)	Use	Remarks
								T. 25 S., R. 31 E.									
4cba	James Stahl	Dr	1962	170	12	90	X	Sandstone, con- glomerate	4,140	36.17	9-11-68	--	N	100	86	U	P 3½ hr, L, Obs.
9cdb	Unknown	Dr	--	105	6	--	--	--	4,109	12.25	10-13-68	--	P	--	--	S	
13cda	Island Ranch	Dr	--	360±	6	--	--	--	4,103	13.64	do	--	S	--	--	S	Water very salty.
27daa	Harney Land Devel. Co.	Dr	1962	179	6	129	P	Clay, cinders	4,110	16.25	9-11-68	--	N	288	63	U	P 3 hr, L.
29ccb	E. L. Koeneman	Dr	1963	209	8	70	P, X	Gravel	4,170	71.07	10-13-68	--	N	100	70	U	P 4 hr, L, Obs.
30dcb	do	Dr	1963	660	12	290	X	Clay	4,150	51.90	do	--	N	52	250	U	B 2 hr, L.
32aaa	Harney Land Devel. Co.	Dr	1962	111	6	70	F	Cinders and gravel	4,113	20.55	do	--	N	314	40	U	P 2 hr, L.
								T. 25 S., R. 32 E.									
7bab	Island Ranch	Dr	1952±	1,345	6	--	--	Clay, sand	4,106	F	5-27-69	1,450	N	3	--	S	C, temp 105°F.
12bab	do	Dr	--	50±	6	--	--	--	4,100	8.60	10-13-68	--	S	--	--	S	
16bcb	do	Dr	--	60	8	--	--	--	4,100	16.88	do	--	S	--	--	S	Pumping.
24bdb	do	Dr	--	60±	6	--	--	--	4,098	10.09	do	3,960	S	--	--	S	C.
35bdb	Clayton King	--	1964?	400±	--	--	--	"Blue mud"	4,097	--	--	3,300	--	--	--	H	Water has bicarbonate taste; C.
								T. 25 S., R. 32½ E.									
3bbb	M. H. Glenn	Dr	1967	91	6	40	X	Sand	4,110	34.20	10-13-68	--	N	20	10	U	B 3 hr, L.
4cdd	Unknown	Dr	--	--	6	--	--	--	4,099	13.15	do	--	S	--	--	S	
14aab	do	--	--	--	6	--	--	--	4,096	10.17	10-15-68	--	P	--	--	S	
25aab	U.S. Fish & Wild- life Service	--	--	--	--	--	--	--	4,095	11.35	do	3,030	S	--	--	S	C.
26aab	do	--	--	--	6	--	--	--	4,095	13.97	do	--	S	--	--	S	

Table 10.--Records of selected wells in the Harney Valley area--Continued

Section Well or spring number	Owner	Type of well	Year com-pleted	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Character of material	Alti-tude (feet)	Water level: Feet below datum	Water level: Date	Specific conduct-ance of water	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Draw-down (feet)	Use	Remarks
T. 25 S., R. 33 E.																	
1cdb	M. F. O'Donell	Dr	1967	205	12	190	X	Cinders, gravel	4,125	16.92	10-15-68	--	--	1,100	64	I	P 8 hr, L.
12abc	Tom Gillespie	Dr	1960	152	12	46	X	Volcanic ash, gravel, sand	4,130	23.17	do	--	T, 15	650	--	I	P, L.
14dcc	Unknown	Dr	--	--	6	--	--	--	4,110	14.30	do	--	J	--	--	S	
T. 25 S., R. 34 E.																	
7bbc	George Hoffman	Dr	1966	402	8	125	X	Sandstone, lava	4,130	29.14	10-15-68	--	T	160	--	I	L.
30dcc	Forrest Skinner	Dr	1957	41	14	20	X	Cinders	4,128	40.3	do	580	T, 25	1,000	2	I	P 12 hr, L, Obs.

APPENDIX III - A, B, C

Chemical Analyses of Waters in the Harney Basin

A. Chemical constituents of representative waters from the Harney basin (From Piper and others, 1939)

B. Chemical analyses of water from representative wells and springs in the Harney Valley area (From Leonard, 1970)

C. Chemical analyses of water samples at miscellaneous sites on Malheur Lake and its tributaries (From Hubbard, 1975)

Appendix III A. Chemical constituents of representative waters from the Harney basin (From Piper and others, 1939)

Samples from wells and springs

Location	Date of collection	Temperature (°F.)	Sum of constituents [1]	Analyses (parts per million): Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) and potassium (K) [2]	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness (as $CaCO_3$) [3]
T. 22 S., R. 32 E.														
NE¼SE¼ sec. 25	Sept. 5, 1931	53	97	....	....	[4] 14	....	16	0	102	[4] 4	2.5	2.0	[5] 57
NE¼NW¼ sec. 34	May 31, 1932	46	315	....	....	24	14	83	0	291	31	20	....	117
T. 22 S., R. 32½ E.														
NE¼SW¼ sec. 14	Sept. 2, 1931	72	72	....	....	[4] 16	....	12	0	86	[4] 4	1.9	1.0	[5] 51
T. 23 S., R. 30 E.														
NE¼SE¼ sec. 12	Aug. 27, 1931	68	[6] 167	59	0.01	14	6.0	18 4.9	0	103	7.5	3.8	2.5	60
NE¼SW¼ sec. 23	Aug. 16, 1931	62	112	....	....	[4] 12	....	15	0	86	[4] 13	10	4.6	[5] 59
NE¼NE¼ sec. 35	Aug. 26, 1931	78	121	....	....	[4] 14	....	37	0	109	[4] 11	8.0	1.1	[5] 33
T. 23 S., R. 31 E.														
NW¼SW¼ sec. 2	May 9, 1932	....	621	....	....	109	36	92	0	650	[4] 5	59	....	420
Lot 2, sec. 4	May 31, 1932	52	156	....	....	28	13	15	0	160	14	7.0	....	123
Lot 8, sec. 6	Sept. 7, 1931	50½	174	....	....	[4] 30	....	26	0	180	[4] 16	3.1	4.6	[5] [illegible]
SE¼SE¼ sec. 9	Aug. 26, 1931	49	191	....	....	[4] 35	....	20	0	180	[4] 29	6.0	2.4	[5] 136
	June 1, 1932	42	369	....	....	107	22	3.6	0	363	38	20	....	358
SE¼SE¼ sec. 9	Aug. 26, 1931	51½	140	....	....	[4] 24	....	21	0	145	[4] 12	1.8	.10	[5] 67
	June 1, 1932	....	147	....	....	28	7.4	19	0	147	18	2.0	....	100
T. 23 S., R. 31 E.														
NW¼NE¼ sec. 14	May 14, 1932	....	114	....	....	20	10	9.8	0	109	18	3.0	....	91
Lot 6, sec. 17	do	....	134	....	....	24	12	12	0	129	25	2.0	....	109
Lot 2, sec. 18	June 1, 1932	....	107	....	....	18	6.6	14	0	100	14	5.0	....	72
Lot 1, sec. 20	May 29, 1932	....	148	....	....	32	9.2	13	0	151	15	3.0	....	118
do	do	....	145	....	....	30	9.6	13	0	149	15	4.0	....	114
SE¼NE¼ sec. 21	May 14, 1932	50	192	....	....	26	14	32	0	214	12	3.0	....	122
do	do	47	150	....	....	20	7.2	31	0	164	9.1	2.0	....	80
T. 23 S., R. 32 E.														
Lot 3, sec. 6	May 31, 1931	46	836	....	....	66	26	250	0	950	[4] 2	21	....	272
NE¼SW¼ sec. 7	Sept. 1, 1931	48	[6] 652	51	0.01	64	22	117 4.0	0	151	175	138	.70	250
SW¼SE¼ sec. 7	do	56	[6] 188	55	.01	11	2.7	38 2.9	0	141	4.7	3.6	1.1	39
SE¼SE¼ sec. 8	May 13, 1932	54	280	....	....	21	12	77	0	278	16	17	....	102
NE¼NW¼ sec. 10	May 31, 1932	60	212	....	....	12	7.6	62	0	185	26	13	....	61
SW¼NE¼ sec. 12	May 9, 1932	....	478	....	....	19	10	168	0	470	[4] 3	47	....	88
Lot 2, sec. 18	May 13, 1932	....	1,196	....	....	164	62	159	0	330	470	175	....	661
SW¼SW¼ sec. 20	Aug. 31, 1931	52	1,303	....	....	154	43	234	0	498	387	109	131	561
do	Sept. 9, 1931	50	281	....	....	[4] 12	....	102	0	321	[4] 2	2.8	4.7	[5] 51
NW¼NE¼ sec. 27	May 13, 1932	50	251	....	....	36	13	38	0	168	73	8.0	....	113
SE¼SE¼ sec. 32	May 28, 1932	....	168	....	....	32	13	17	0	191	10	2.0	....	133
T. 23 S., R. 32½ E.														
Lot 4, sec. 2	May 9, 1932	....	322	....	....	8.5	7.0	116	0	312	18	19	....	50
Lot 1, sec. 31	Sept. 5, 1931	51	481	....	....	[4] 2	....	198	0	438	[4] 60	17	3.7	[5] 18
do	do	50	[6] 219	51	0.01	29	9.2	21 8.1	0	176	11	4.2	.8	108
NW¼SE¼ sec. 32	May 13, 1932	52	210	....	....	14	15	51	0	229	12	5.0	....	96
NE¼NW¼ sec. 35	May 31, 1932	49	1,045	....	....	38	31	343	0	910	102	83	....	222
T. 23 S., R. 33 E.														
NE¼SW¼ sec. 22	Sept. 2, 1931	52	715	....	....	32	14	219	0	453	88	64	75	137
NE¼NW¼ sec. 33	May 9, 1932	....	1,510	....	....	46	22	483	12	299	490	340	....	205
T. 24 S., R. 30 E.														
Lot 2, sec. 1	Aug. 26, 1931	80	[6] 159	61	.01	9.6	1.7	30 2.4	0	95	13	5.2	1.2	31
SE¼NE¼ sec. 2	May 14, 1932	51	215	....	....	9.0	7.0	70	0	221	16	3.0	....	51
SE¼SW¼ sec. 11	Aug. 25, 1931	72	113	....	....	[4] 7	....	40	0	101	[4] 13	5.0	.30	[5] 18
NE¼NE¼ sec. 18	May 25, 1932	....	123	....	....	14.0	2.4	31	0	100	17	9.0	....	45
T. 24 S., R. 31 E.														
SE¼NE¼ sec. 8	May 11, 1932	54	112	....	....	5.0	4.4	35	0	107	6.6	8.0	....	31
do	May 10, 1932	46	619	....	....	29	18	188	0	298	175	92	....	146
SE¼SW¼ sec. 10	Sept. 8, 1931	51	318	....	....	45	....	77	0	358	[4] 21	12	1.1	[5] 169
SW¼SW¼ sec. 12	May 14, 1932	....	352	....	....	51	20	63	0	380	24	7.0	....	210
NE¼SE¼ sec. 20	Sept. 4, 1931	51	1,182	....	....	73	33	317	0	307	274	334	....	318
do	May 10, 1932	46	417	....	....	34	15	126	0	339	49	26	....	146

Samples from wells and springs—Continued

Location	Date of collection	Temperature (°F.)	Sum of constituents [1]	Analyses (parts per million) Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) and potassium (K)[1]	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness (as $CaCO_3$)[2]
T. 24 S., R. 32 E.														
NE¼SE¼ sec. 5	May 28, 1932	50	427	-------	-------	10	7.9	161	25	426	6.2	7.0	-------	57
NW¼SE¼ sec. 9	May 14, 1932	-------	816	-------	-------	8.5	6.6	312	61	538	126	37	-------	48
NW¼NE¼ sec. 23	May 11, 1932	52	1,046	-------	-------	18	23	383	20	909	61	93	-------	139
SE¼SW¼ sec. 23	May 11, 1932	52	1,626	-------	-------	46	56	550	0	925	633	85	-------	345
SE¼SW¼ sec. 26	May 31, 1932	49	1,404	-------	-------	19	22	496	19	841	314	120	-------	138
SE¼NE¼ sec. 31	Sept. 4, 1931	55	465	-------	-------	[4] 7	-------	195	0	524	[4] 4	14	.40	[4] 30
do	do	48	663	-------	-------	[4] 25	-------	230	45	596	[4] 8	49	.20	[4] 140
T. 24 S., R. 32½ E.														
NW¼SE¼ sec. 7	May 13, 1932	-------	3,230	-------	-------	106	129	871	0	1,154	1,166	375	-------	794
NW¼NW¼ sec. 10	do	54	388	-------	-------	19	9.4	130	9.8	389	16	12	-------	86
SW¼NW¼ sec. 32	Sept. 4, 1931	57	1,205	-------	-------	[4] 12	-------	492	0	1,031	[4] 3	212	.25	[4] 80
NE¼NE¼ sec. 33	May 11, 1932	-------	1,366	-------	-------	63	68	408	0	1,392	[4] 14	172	-------	436
T. 24 S., R. 33 E.														
NW¼SE¼ sec. 34	Aug. 30, 1931	120	427	-------	-------	[4] 2	-------	171	22	173	[4] 80	82	1.4	[4] 6
NE¼SW¼ sec. 34	May 11, 1932	54	1,193	-------	-------	15	5.2	429	16	531	347	119	-------	59
T. 25 S., R. 31 E.														
SE¼SW¼ sec. 9	Sept. 4, 1931	51	413	-------	-------	[4] 14	-------	158	0	410	[4] 35	14	.30	[4] 48
NE¼SE¼ sec. 33	May 18, 1932	56	1,421	-------	-------	144	65	351	0	1,539	48	55	-------	626
T. 25 S., R. 32 E.														
Lot 1 sec. 2	May 31, 1932	-------	859	-------	-------	31	44	234	79	418	222	43	-------	258
do	do	-------	2,126	-------	-------	225	108	313	0	425	1,230	41	-------	1,005
Lot 3 sec. 35	Sept. 8, 1931	52	1,731	-------	-------	45	93	490	0	1,292	358	104	-------	514
T. 25 S., R. 32½ E.														
SE¼SW¼ sec. 1	May 25, 1932	-------	448	-------	-------	7.0	5.5	172	21	317	5.3	81	-------	40
Lot 3 sec. 5	Sept. 2, 1931	52	1,568	-------	-------	85	72	392	0	903	499	68	7.4	508
NE¼SW¼ sec. 8	May 30, 1932	52	1,769	-------	-------	38	71	498	31	769	740	12	-------	386
NW¼NW¼ sec. 11	May 11, 1932	-------	5,810	-------	-------	34	58	2,157	368	2,560	1,141	790	-------	323
Lot 5 sec. 19	May 19, 1932	49	1,628	-------	-------	111	140	278	0	919	559	87	-------	852
Lot 1, sec. 20	May 19, 1932	52	6,139	-------	-------	212	322	1,396	0	1,081	3,160	505	-------	1,850
Lot 7 sec. 22	May 24, 1932	-------	404	-------	-------	65	22	53	0	273	104	25	-------	253
do	do	-------	454	-------	-------	22	27	103	48	90	165	45	-------	166
(?)	do	-------	1,564	-------	-------	123	107	327	0	1,284	331	43	-------	746
T. 25 S., R. 33 E.														
SE¼SW¼ sec. 6	May 11, 1932	-------	687	-------	-------	36	20	212	0	565	79	62	-------	172
NW¼NW¼ sec. 23	do	-------	712	-------	-------	5.5	6.1	265	76	417	91	211	-------	39
T. 26 S., R. 28 E.														
NW¼NE¼ sec. 14	May 30, 1932	54	237	-------	-------	9.5	3.9	85	0	241	4.9	15	-------	40
T. 26 S., R. 29 E.														
NW¼SE¼ sec. 27	do	52	437	-------	-------	8.0	7.4	166	0	425	4.9	41	-------	50
Lot 4 sec. 31	Aug. 21, 1931	68	[6] 230	60	0.01	14	7.5	41 4.2	0	134	14	24	1.1	66
T. 26 S., R. 31 E. "North of Malheur Lake" and T. 25 S., R. 30 E. "South of Malheur Lake"														
SE¼SE¼ sec. 3	May 17, 1932	-------	27,500	-------	-------	717	341	8,510	153	3,770	11,060	4,850	-------	3,190
SE¼SE¼ sec. 15	May 26, 1932	-------	6,370	-------	-------	4.5	25	2,640	511	4,990	299	428	-------	114
SW¼NE¼ sec. 26	May 18, 1932	52	1,694	-------	-------	50	137	453	0	1,800	102	65	-------	687
Lot 2 sec. 32	do	52	11,490	-------	-------	327	348	3,150	0	1,172	5,020	2,065	-------	2,244
NW¼SW¼ sec. 35	Sept. 8, 1931	52½	4,138	-------	-------	[3] 14	[4] 58	1,630	0	1,804	570	1,148	.25	[3] 154
do	do	54	485	-------	-------	[3] 3	[4] 0	207	13	353	[3] 3	101	1.5	[4] 7.5
T. 26 S., R. 32 E. "North of Malheur Lake" and T. 26 S., R. 31 E. "South of Malheur Lake"														
(?)	May 19, 1932	51	2,468	-------	-------	30	162	650	0	1,346	795	158	-------	739
(?)	Sept. 8, 1931	50	2,626	-------	-------	76	133	744	0	1,624	560	311	2.0	735
(?)	May 19, 1932	51	4,480	-------	-------	468	294	615	0	1,140	2,204	335	-------	2,363
NE¼NE¼ sec. 18	May 18, 1932	51	2,371	-------	-------	10	18	964	40	1,936	[3] 5	380	-------	99
do	do	52	7,100	-------	-------	7.0	2.0	2,840	449	4,370	1,221	425	-------	26
(?)	Sept. 8, 1931	50	746	-------	-------	87	67	122	0	864	[3] 32	12	.70	492
Lot 6 sec. 31	May 20, 1932	-------	311	-------	-------	34	27	55	0	348	12	12	-------	196
Lot 6 sec. 35	Aug. 22, 1931	55	[6] 226	41	.01	20	13	31 3.9	0	195	8.6	7.4	.62	103

Samples from wells and springs—Continued

Location	Date of collection	Temperature (°F.)	Sum of constituents [1]	Analyses (parts per million): Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) and potassium (K) [2]	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness (as $CaCO_3$) [3]
T. 26 S., R. 32 E. "South of Malheur Lake"														
(7)	May 16, 1932	56	634	-------	-------	44	11	180	15	227	133	139	-------	155
(7)	May 25, 1932	51	213	-------	-------	16	5.9	75	18	175	17	25	-------	64
NW¼SE¼ sec. 34	Aug. 22, 1931	54	168	-------	-------	[3] 18	[4] 12	42	0	163	[4] 8	13	.50	[5] 70
T. 26 S., R. 33 E.														
(7)	Sept. 8, 1931	52	2,502	-------	-------	24	86	863	63	1,761	280	318	1.0	413
(7)	do	50	2,374	-------	-------	17	48	878	124	1,396	202	417	.50	239
Lot 3 sec. 17	May 16, 1932	52	272	-------	-------	20	7.2	78	0	187	26	49	-------	80
Lot 13 sec. 22	do	50	20,930	-------	-------	5.0	6.1	8,270	2,168	7,510	3,530	3,250	-------	38
SE¼SW¼ sec. 26	do	54	282	-------	-------	1.5	2.4	111	55	131	33	15	-------	14
NE¼NE¼ sec. 27	do	51	63,000	-------	-------	2.9	44	21,810	546	4,020	30,100	8,560	-------	188
T. 27 S., R. 29 E.														
SW¼SW¼ sec. 3	Aug. 21, 1931	53	193	-------	-------	[3] 16	[4] 17	47	0	143	[4] 24	25	.05	[5] 75
	May 30, 1932	52	194	-------	-------	19	10	42	0	137	29	27	-------	88
Lot 4 sec. 5	Aug. 21, 1931	68	212	-------	-------	13	4.1	67	16	134	20	26	-------	49
T. 27 S., R. 29½ E.														
NE¼SE¼ sec. 36	do	139	[6] 1,782	92	.03	13	3.0	622 12	0	601	140	562	.50	45
T. 27 S., R. 30 E.														
Lot 4 sec. 4	do	65½	680	-------	-------	[3] 1	[4] 0	298	89	423	[4] 20	90	.25	[5] 0
Lot 7 sec. 8	May 18, 1932	54	5,460	-------	-------	5.0	4.6	2,100	227	1,343	962	1,500	-------	31
T. 27 S., R. 31 E.														
NE¼NE¼ sec. 5	May 10, 1932	51	246	-------	-------	24	12	60	0	268	12	6.0	-------	109

Samples from streams and from Harney Lake

Location	Date of collection	Temperature (°F.)	Sum of constituents [1]	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) and potassium (K) [2]	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness (as $CaCO_3$) [3]
T. 23 S., R. 31 E.														
Lot 8 sec. 6	May 12, 1932	-------	122			29	6.8	8.3	0	121	17	1.0	-------	100
T. 24 S., R. 31 E.														
NW¼NW¼ sec. 21	May 10, 1932	66	165	-------	-------	21	7.9	35	0	177	11	3.0	-------	85
T. 24 S., R. 32 E.														
NW¼NW¼ sec. 21	May 14, 1932	-------	172	-------	-------	34	11	18	0	179	19	2.0	-------	130
T. 25 S., R. 32 E.														
SE¼SW¼ sec. 24	May 10, 1932	66	172	-------	-------	36	10	17	0	175	21	2.0	-------	131
T. 26 S., R. 31 E., "South of Malheur Lake"														
Lot 6 sec. 35	May 20, 1932	-------	88	-------	-------	16	5.0	12	0	94	7.0	2.0	-------	60
Harney Lake	Aug. 5, 1902	-------	8,851	29	0	0	6.8	3,604 193	0	3,007	773	2,771	-------	-------

1 Silica (SiO_2), iron (Fe), and nitrate (NO_3) not included.
2 Calculated except for analyses in which sodium (Na) and potassium (K) are entered separately.
3 Calculated except as indicated.
4 By turbidity.
5 By soap method.
6 Total dissolved solids at 180° C.
7 Unsurveyed land within meander line of Malheur and Harney "lakes."
8 Russell, I. C., Notes on the geology of southwestern Idaho and southeastern Oregon: U. S. Geol. Survey Bull. 217, p. 31, 1903; George Steiger, analyst.

A. Silvies River near apex of alluvial fan.
B. West Fork of Silvies River 6½ miles south of Burns, opposite Sagehen Valley.
C. East Fork of Silvies River, 5½ miles northwest of Lawen.
D. West Fork of Silvies River, 5 miles south of Lawen.
E. Donner und Blitzen River near mouth, 6 miles east of Narrows.
F. Sample taken by I. C. Russell.

Appendix III B. Chemical analyses of water from representative wells and springs in the Harney Valley area. (From Leonard, 1970)

				Milligrams per liter														Dissolved solids		Hardness as $CaCO_3$				Temperature			
Sample no.	Location number	Depth of well (feet)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Arsenic (As)	Boron (B)	Residue on evaporation at 180°C	Calculated	Calcium magnesium	Noncarbonate	Specific conductance (micromhos per cm at 25°C)	pH	(°F)	(°C)	Percent sodium	Sodium-adsorption-ratio (SAR)
1	22S/30E-27ddc	127	7-23-68	55	0.01	10	4.8	13	4.5	82	0	5.2	2.5	0.2	2.5	--	0.05	139	138	44	0	161	7.5	57	14	44	0.9
2	22S/31E-34aaa	725	do	60	.04	23	4.8	22	5	124	0	16	8.5	.4	3.3	--	.11	193	204	77	0	261	7.7	58	14	41	1.1
3	22S/32E-34aaa1	1,000	9-13-68	89	.03	1	.2	157	1.8	49	92	89	38	2.8	0	0.06	3.99	515	499	4	0	716	9.5	172	72	99	36
4	22S/32½E-30cdb	647	7-25-68	61	.06	16	4.4	39	3.7	154	0	12	5.5	.6	1.9	--	.11	211	220	58	0	279	8	--	--	61	2
5	-36aab	182	7-25-68	63	.04	24	8.1	40	8	190	0	23	7.5	.4	.4	--	.11	257	268	94	0	367	7.5	58	14	51	1.8
6	23S/30E-23cda	345	7-24-68	60	.05	15	5.7	35	6.9	128	0	18	13	.5	3.8	--	.53	212	221	61	0	289	7.8	64	17	58	1.2
7	-35aad	200	do	55	.02	11	2	33	4	105	0	14	7	.5	1.5	--	.38	179	180	36	0	222	7.8	76	25	69	2.4
8	-35ddd(s)	Spring	9-13-68	46	.02	8.2	1.4	35	3.2	92	0	16	7	.6	2.1	--	.23	167	165	26	0	210	7.5	72	22	74	.81
9	23S/31E-5acc	400	7-23-68	58	.30	25	10	13	4.1	143	0	14	3	.4	1.4	--	.09	190	199	104	0	270	7.4	52	11	24	.56
10	-24aac	114	7-24-68	40	.28	21	6.2	32	4.3	164	0	15	5	.3	.2	--	.16	204	205	78	0	295	7.7	51	11	49	1.4
11	23S/32E-7cab	93	6-12-69	51	--	21	4.5	22	3.6	137	2	3.6	3.5	.4	.2	.01	--	182	179	71	0	226	8.3	51	11	[illegible]	1.25
12	-28acd	250	7-23-68	52	.34	5.4	3.9	172	5.6	472	0	.4	16	.8	1.9	--	1	511	491	30	0	771	7.6	60	16	93	14
13	24S/30E-1abd	564	9-11-68	45	0	8.8	1.4	31	2.9	93	0	12	5	.5	1.1	--	.06	158	155	28	0	194	8.1	80	27	72	2.6
14	24S/32E-5aad	270	7-23-68	44	3.2	5.9	4.2	160	5.8	450	0	3.2	7	1.1	2.1	.04	1.5	458	456	32	0	684	8	55	13	92	12
15	-8dab	2,812	9-12-68	72	.20	.8	.2	135	1.6	94	84	29	11	12	.2	--	4.11	427	396	3	0	602	9.6	115	46	99	39
16	24S/32½-13acb	242	7-24-68	53	.21	5.4	4.6	255	14	504	0	2.6	117	6	14	.04	8.9	726	729	32	0	1,170	7.5	58	14	95	19
17	-22bcc	--	6-11-69	53	--	55	44	113	18	552	0	105	35	.4	5.1	--	--	762	711	343	0	1,040	7.9	54	12	44	2.9
18	-30add1/	185	do	60	2.3	12	40	724	33	1,430	0	0	478	1.2	58	.00	6.7	1,990	2,120	194	0	3,200	7.8	58	14	89	23
19	24S/33E-24aac	340	7-25-68	60	.89	97	32	706	28	348	0	269	975	.5	1.4	--	4.8	2,360	2,350	374	88	4,000	7.8	--	--	81	16
20	-34cca(s)	Spring	9-12-68	80	.02	3.8	.2	170	3.6	199	6	81	78	9.3	0	--	6.2	545	536	10	0	814	8.3	176	80	97	23
21	24S/34E-31bac	91	6-12-69	53	--	65	19	37	4.5	249	0	55	41	.2	5.1	.00	--	410	403	240	35	611	7.9	53	12	27	1.12
22	-31dda	305	do	53	--	32	8.1	20	3.5	170	0	11	4.5	.3	2.9	.00	--	205	219	114	0	296	8	53	12	30	.9
23	25S/32E-7bab	1,345	do	54	--	.5	.2	366	4.4	674	144	8	9	19	.1	.00	--	938	957	2	0	1,450	9.3	105	41	100	120
24	-24bdb	60	do	40	--	95	177	662	31	635	0	1,550	195	.6	25	.00	--	3,110	3,090	965	444	3,960	7.4	51	11	61	9.5
25	-35bdb	400±	do	72	--	6.4	36	835	28	2,000	0	0	236	1.4	65	.00	--	2,240	2,260	164	0	3,300	7.6	--	--	92	35
26	25S/32½E-21aab	--	do	52	--	11	22	681	19	888	0	5.2	630	1.4	19	.00	--	1,900	1,880	118	0	3,030	7.6	53	12	93	29

1/ Also contained 6.1 mg/l of aluminum, 0.18 mg/l of manganese, 0.04 mg/l of copper, and 0.07 mg/l of zinc.

Appendix III C. Chemical analyses of water samples at miscellaneous sites on Malheur Lake and its tributaries. (From Hubbard, 1975)

Date of collection	Discharge (ft^3/s)	Silica (SiO_2) (mg/l)	Iron (Fe) (ug/l)	Manganese (Mn) (ug/l)	Calcium (Ca) (mg/l)	Magnesium (Mg) (mg/l)	Sodium (Na) (mg/l)	Potassium (K) (mg/l)	Bicarbonate (HCO_3) (mg/l)	Carbonate (CO_3) (mg/l)	Sulfate (SO_4) (mg/l)	Chloride (Cl) (mg/l)
									West Fork Silvies River			
Mar. 31, 1972	285	36	100	--	29	7.9	26	5.5	165	0	17	3.4
									East Fork Silvies River			
Mar. 31, 1972	109	36	70	--	29	8.2	18	4.9	160	0	12	2.7
June 22, 1972	5.4	31	40	0	50	16	59	8.8	349	0	32	8.3
Feb. 9, 1973	10	31	50	10	26	7.7	15	3.4	149	0	18	3.1
Apr. 17, 1973	.06	27	50	0	41	11	23	4.8	206	0	25	5.2
									Donner und Blitzen River			
Mar. 31, 1972	194	29	110	--	11	4.8	9.2	1.9	73	0	4.0	2.1
June 22, 1972	42	24	150	100	16	6.9	11	1.3	102	0	8.7	1.2
Feb. 8, 1973	93	27	50	10	9.9	4.3	8.5	1.4	71	0	4.9	1.8
Apr. 17, 1973	15	25	150	0	9.3	3.8	6.3	1.6	58	0	3.7	2.0
June 13, 1973	12	25	50	0	11	5.1	11	1.8	81	0	7.6	.5
									Malheur Lake at break in			
Mar. 29, 1972	--	6.1	40	--	61	20	36	11	364	0	8.7	7.1
June 21, 1972	--	2.1	60	50	49	28	84	20	478	0	34	14
Apr. 17, 1973	--	17	70	0	54	37	100	28	583	0	22	19
June 13, 1973	--	15	70	10	56	43	140	35	729	0	39	24
									Malheur Lake on east side of			
Mar. 29, 1972	--	27	80	--	11	17	450	50	921	83	160	63
June 21, 1972	--	39	70	10	18	25	590	68	1410	113	190	84
Feb. 5, 1973	--	32	50	0	20	52	200	23	582	30	100	40
Apr. 17, 1973	--	29	100	0	11	17	950	67	1750	145	350	170
June 13, 1973	--	26	90	10	12	24	1700	130	2740	441	600	320
									Malheur Lake on west side of			
Mar. 29, 1972	--	27	130	--	18	8.8	43	5.6	177	0	12	8.6
June 21, 1972	--	7.1	100	--	46	25	78	12	457	0	15	15
Feb. 5, 1973	--	12	80	20	41	32	130	12	484	0	57	30
Apr. 17, 1973	--	17	70	0	45	41	210	20	755	0	70	39
June 13, 1973	--	15	70	0	32	55	380	29	573	265	83	70

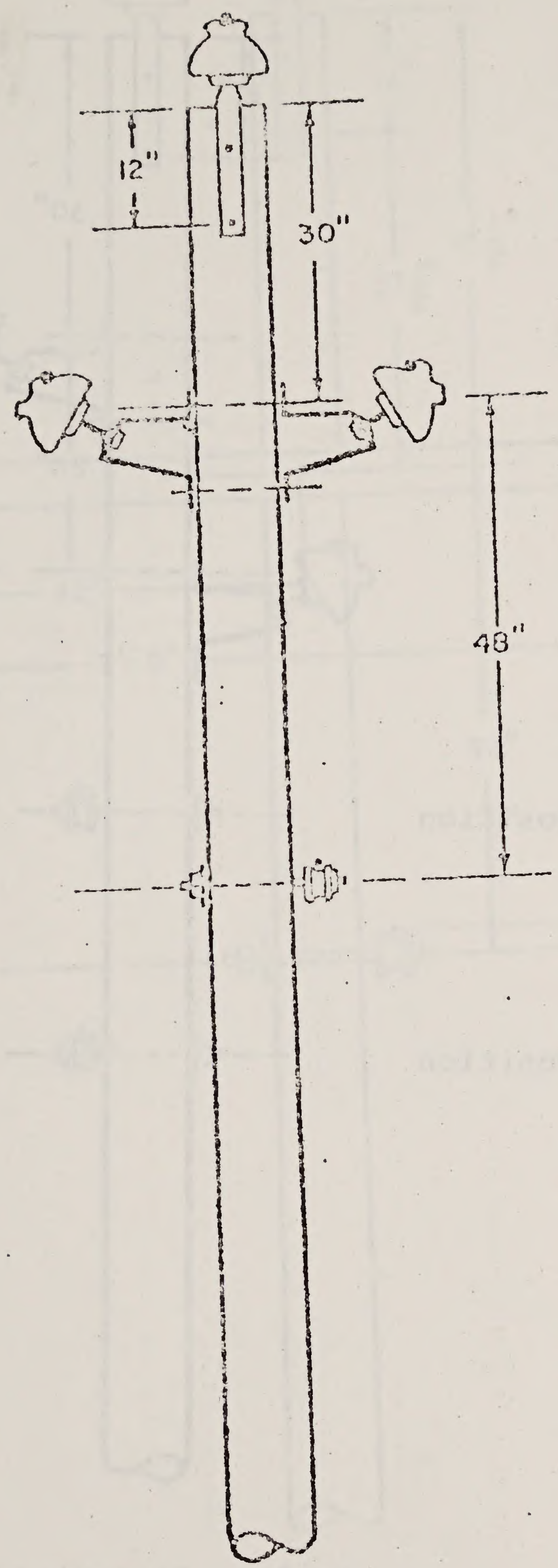
Fluoride (F) (mg/l)	Nitrite + nitrate (N) (mg/l)	Kjeldahl nitrogen (N) (mg/l)	Total nitrogen (N) (mg/l)	Orthophosphorus (P) (mg/l)	Total phosphorus (P) (mg/l)	Hardness (Ca, Mg) (mg/l)	Noncarbonate hardness (mg/l)	Dissolved solids (sum of constituents) (mg/l)	Copper (Cu) (ug/l)	Zinc (Zn) (ug/l)	Sodium-adsorption-ratio	Percent sodium	Specific conductance (micromhos at 25°C)	pH (units)
at Narrows (site 8)														
0.5	0.02	--	--	--	--	160	0	268	--	--	1.3	32	442	7.6
.6	.01	.95	.96	0.01	0.05	210	0	320	--	--	1.2	29	555	7.6
.9	.00	--	--	.01	.05	310	0	551	17	150	2.1	36	893	--
.6	.16	--	--	--	.16	220	0	364	--	--	1.4	31	602	7.9
1.2	.17	1.6	1.8	.01	.01	190	0	319	--	--	1.4	32	503	7.8
(site 9)														
.6	.01	--	--	--	.09	190	0	333	3	20	1.6	36	560	7.8
.8	.03	1.6	1.6	.02	.12	230	0	563	--	--	3.1	47	936	8.1
1.0	.05	--	--	--	.25	250	0	659	--	--	3.9	51	998	8.4
(site 11)														
.4	.00	--	--	--	--	140	0	263	--	--	1.3	33	416	7.6
.5	.00	1.1	1.1	.00	.02	180	0	297	--	--	1.4	32	513	8.1
.6	.01	--	--	--	.06	220	0	335	--	--	1.1	26	573	8.0
.8	.45	1.1	2.3	.02	.04	210	0	335	--	--	1.3	29	559	--
(site 12)														
.3	.00	.48	.48	--	.05	110	0	166	7	20	.6	21	280	7.6
.3	.03	.86	.89	.00	.04	170	0	230	--	--	.8	23	394	8.1
.4	.00	--	--	--	.09	150	0	232	--	--	.8	23	397	7.8
1.5	.24	.95	1.3	.01	--	160	0	259	--	--	1.2	31	450	8.1
(site 13)														
.5	.01	--	--	--	--	180	0	325	--	--	1.7	37	522	7.9
.7	.01	1.5	1.5	.00	.09	220	0	382	--	--	1.6	34	623	8.2
.8	.01	--	--	--	.13	260	0	495	--	--	2.4	40	798	8.1
1.0	.42	1.6	2.2	.04	.06	280	0	549	--	--	2.6	41	906	8.1
(site 14)														
.3	.00	--	--	--	--	120	0	168	--	--	.6	21	282	7.6
.3	.01	--	--	--	.07	140	0	196	--	--	.7	22	335	7.7
Voltage (site 15)														
.6	.38	--	--	--	.18	110	0	237	5	10	1.5	40	361	7.8

Fluoride (F) (mg/l)	Nitrite + nitrate (N) (mg/l)	Kjeldahl nitrogen (N) (mg/l)	Total nitrogen (N) (mg/l)	Orthophosphorus (P) (mg/l)	Total phosphorus (P) (mg/l)	Hardness (Ca, Mg) (mg/l)	Noncarbonate hardness (mg/l)	Dissolved solids (sum of constituents) (mg/l)	Copper (Cu) (ug/l)	Zinc (Zn) (ug/l)	Sodium-adsorption-ratio	Percent sodium	Specific conductance (micromhos at 25°C)	pH (units)
near Lawen (site 2)														
0.3	0.00	--	--	--	--	100	0	206	--	--	1.1	34	296	7.6
near Lawen (site 3)														
.2	.01	--	--	--	--	110	0	190	--	--	.8	26	279	7.6
.5	.00	1.9	1.9	0.03	0.23	190	0	377	--	--	1.9	39	593	8.0
.1	.00	--	--	.04	.08	97	0	178	4	0	.7	24	269	7.7
.2	.00	--	--	--	.21	150	0	239	--	--	.8	25	371	7.7
near Voltage (site 4)														
.1	.07	--	--	--	--	47	0	98	--	--	.6	29	124	7.5
.1	.05	.51	.56	.03	.12	68	0	120	--	--	.6	25	170	7.6
.1	.23	--	--	.03	.11	42	0	94	7	0	.6	30	119	8.2
.0	.29	--	--	--	.10	39	0	82	--	--	.4	25	107	7.7
.4	.24	.35	1.1	.05	.10	48	0	104	--	--	.7	32	129	7.8
Cole Island Dike (site 5)														
.6	.01	.78	.79	--	.05	230	0	330	--	--	1.0	24	573	7.5
.8	.01	1.6	1.6	.01	.08	240	0	467	--	--	2.4	41	788	7.8
.9	.01	--	--	--	.08	290	0	565	--	--	2.6	40	937	7.8
1.4	.56	1.9	2.6	.07	.08	320	0	716	--	--	3.4	46	1180	8.1
Cole Island Dike (site 6)														
1.1	.00	--	--	--	--	97	0	1320	--	--	20	86	2040	8.7
1.3	.00	3.0	3.0	.11	.36	150	0	1820	--	--	21	85	2640	8.8
1.0	.00	--	--	.03	.09	260	0	785	8	130	5.4	60	1090	8.3
1.9	.14	--	--	--	.97	97	0	2600	--	--	42	92	3540	8.9
3.3	2.8	8.0	11	1.2	1.3	130	0	4620	--	--	65	93	6770	8.9
Cole Island Dike (site 7)														
.4	.00	--	--	--	--	81	0	211	--	--	2.1	51	304	7.6
.9	.00	1.7	1.7	.01	.15	220	0	424	--	--	2.3	42	713	--
1.1	.00	--	--	.03	.08	230	0	554	18	160	3.7	53	840	7.9
1.6	.05	--	--	--	.26	280	0	816	--	--	5.5	60	1260	--
2.3	1.1	3.7	4.8	.12	.19	310	0	1220	--	--	9.4	71	1880	8.7

Date of collection	Discharge (ft^3/s)	Silica (SiO_2) (mg/l)	Iron (Fe) (ug/l)	Manganese (Mn) (ug/l)	Calcium (Ca) (mg/l)	Magnesium (Mg) (mg/l)	Sodium (Na) (mg/l)	Potassium (K) (mg/l)	Bicarbonate (HCO_3) (mg/l)	Carbonate (CO_3) (mg/l)	Sulfate (SO_4) (mg/l)	Chloride (Cl) (mg/l)
Malheur Lake Outlet												
Mar. 31, 1972	176	19	550	--	36	16	36	9.1	266	0	13	7.7
June 22, 1972	103	13	110	82	48	21	41	8.9	354	0	7.6	5.2
Feb. 8, 1973	6.0	22	110	20	58	39	84	18	534	0	48	18
Apr. 17, 1973	10	19	60	0	51	23	49	13	366	0	15	12
June 13, 1973	8.8	28	140	20	44	19	43	9.9	316	0	11	5.8
Malheur Lake												
Mar. 28, 1972	--	13	80	--	43	20	52	11	338	0	17	9.4
June 21, 1972	--	14	60	30	43	31	110	25	569	0	40	19
Apr. 24, 1973	--	22	40	0	41	35	140	34	554	49	41	23
Malheur Lake												
Mar. 28, 1972	--	29	100	--	35	13	35	8.7	237	0	19	6.4
June 21, 1972	--	1.5	40	0	45	17	43	9.6	313	0	20	6.6
Apr. 24, 1973	--	14	30	0	54	21	39	12	363	0	7.6	7.4
July 14, 1973	--	12	30	0	48	23	44	13	351	0	10	8.8
Malheur Lake												
Mar. 28, 1972	--	14	30	--	31	8.7	14	3.5	177	0	4.1	2.8
June 21, 1972	--	1.7	30	0	45	13	24	4.9	262	0	7.8	4.0
Apr. 24, 1973	--	17	20	0	42	12	22	6.0	249	0	5.2	4.4
July 14, 1973	--	8.1	50	0	36	17	36	9.0	275	0	7.3	7.4
Malheur Lake												
Mar. 28, 1972	--	21	60	--	41	18	51	11	308	0	21	9.9
June 21, 1972	--	18	30	0	49	24	56	14	383	0	22	9.7
Apr. 24, 1973	--	17	50	0	53	30	87	23	499	0	23	15
July 14, 1973	--	21	230	0	53	35	98	24	547	0	26	19
Malheur Lake												
Mar. 28, 1972	--	14	20	--	34	8.2	15	3.6	174	0	4.0	3.2
Apr. 24, 1973	--	13	9	0	38	9.9	18	4.1	210	0	4.9	3.8
Sodhouse Spring near												
Oct. 16, 1973	12	40	50	--	22	13	35	4.8	208	0	10	7.3

APPENDIX B

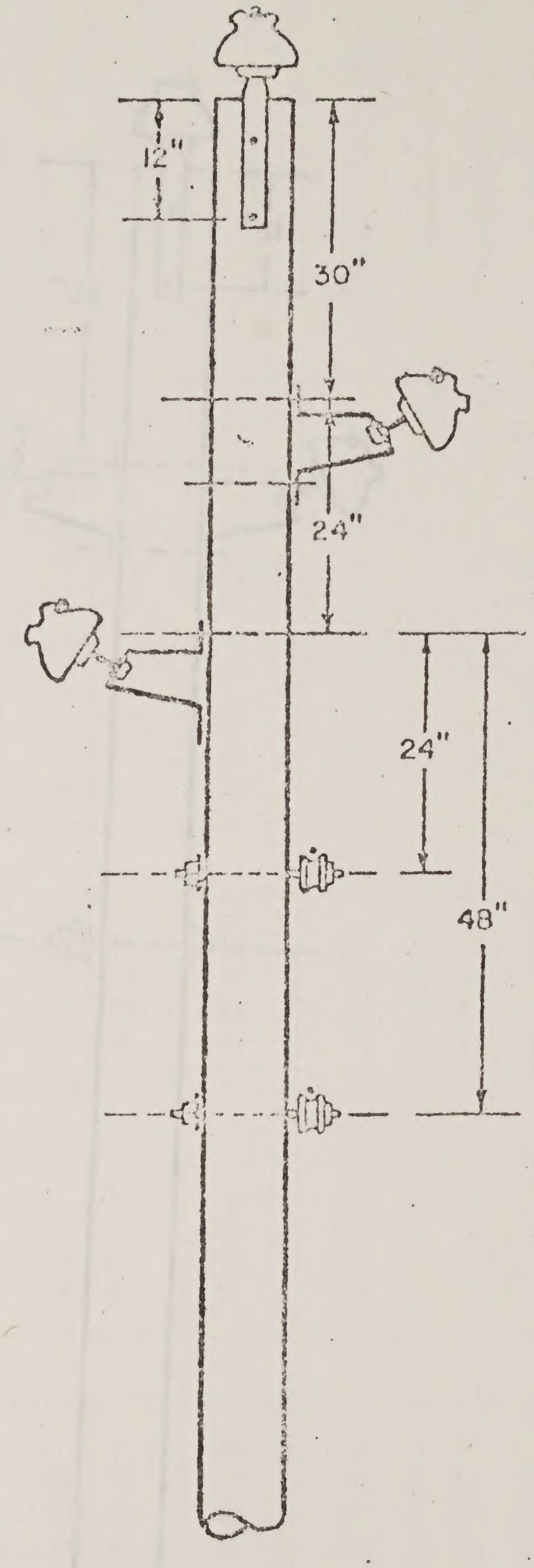
POWER LINE SPECIFICATIONS



Armless Distribution
Triangular Construction

...proved type structure
... be installed in a
...irds of Prey" area

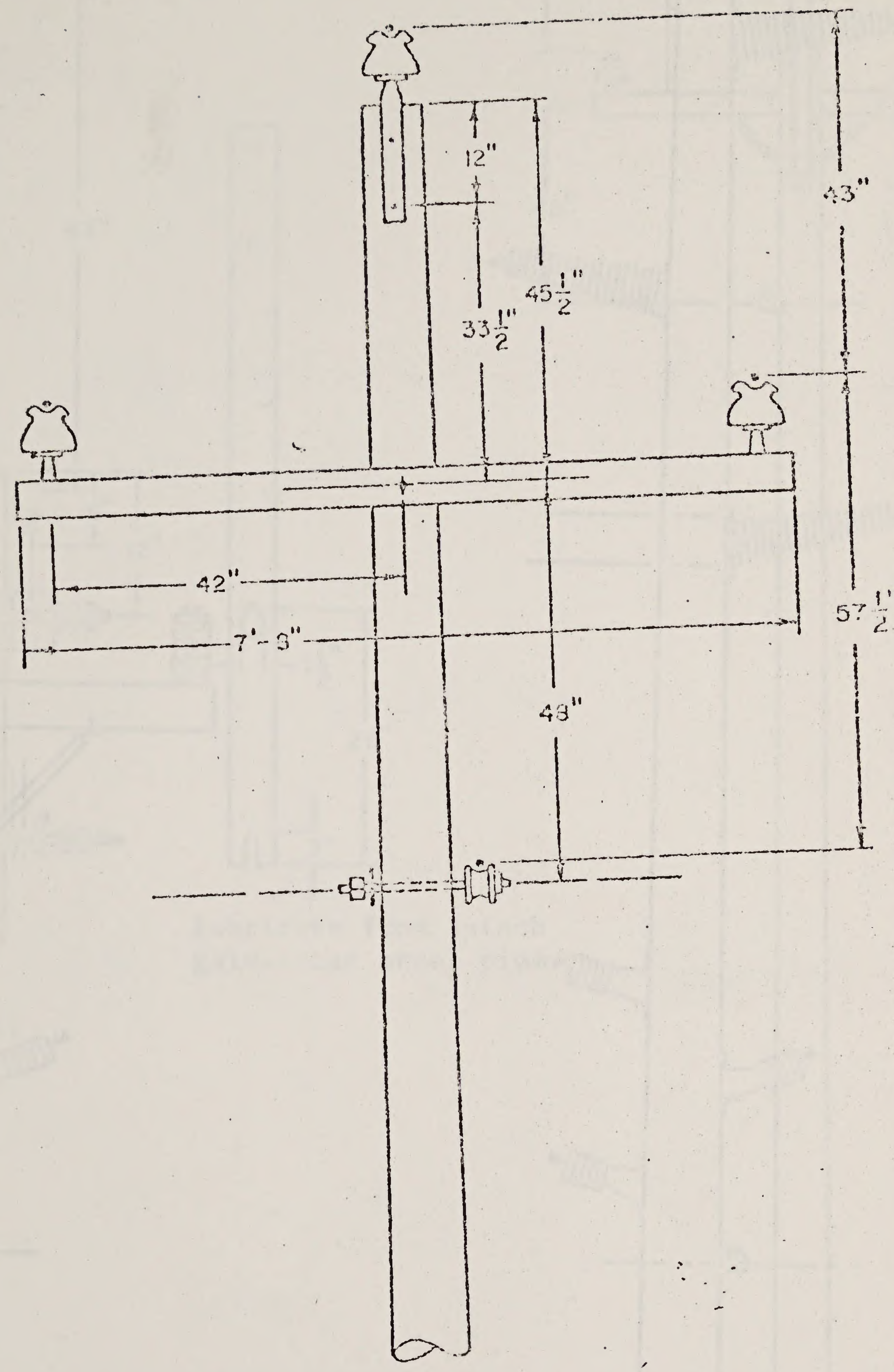
B-1



Armless Distribution
Staggered Construction

Approved type structure
to be installed in a
"Birds of Prey" area

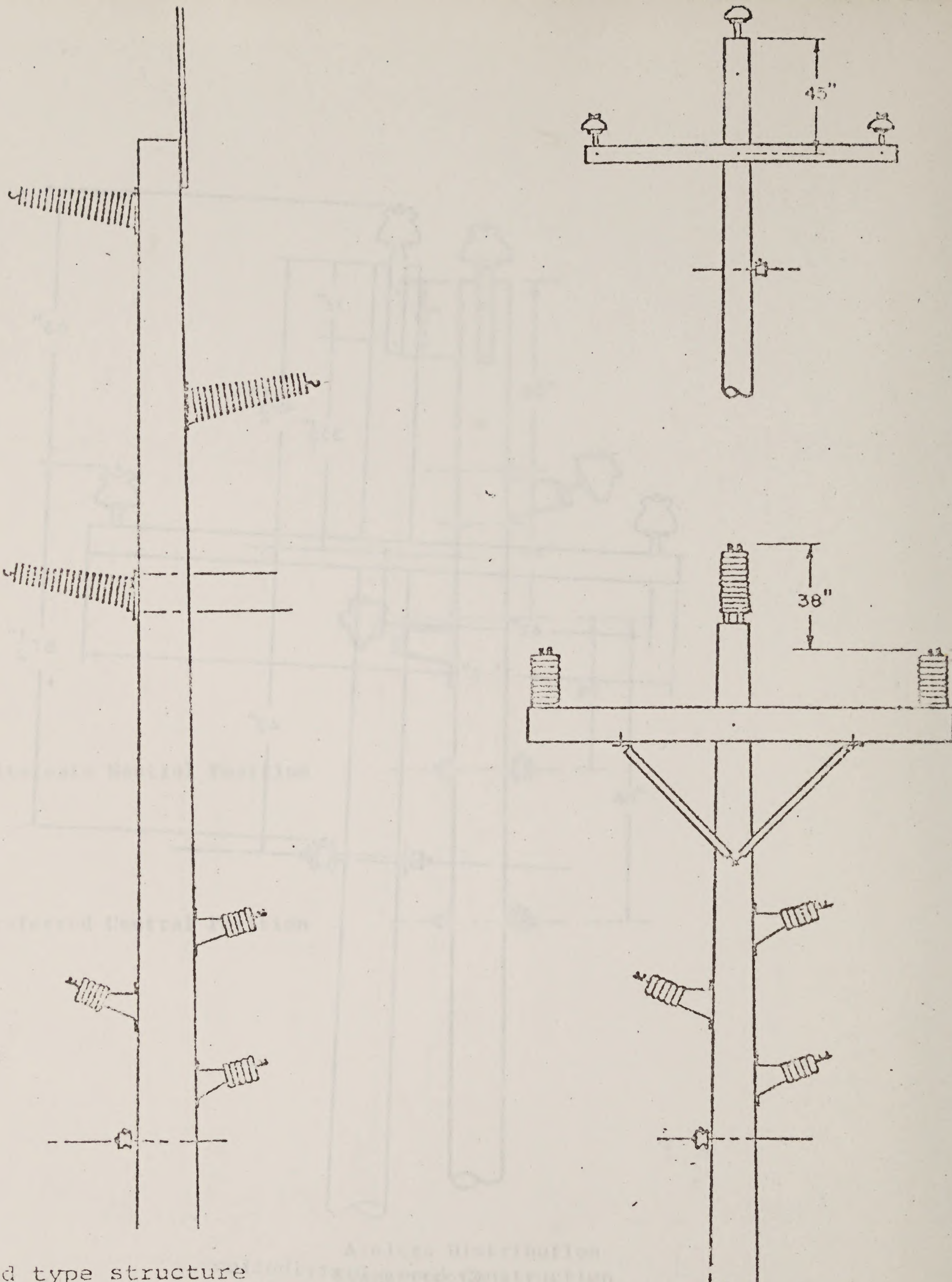
Birds-of-Prey Consultant



Crossarm Distribution
Triangular Construction

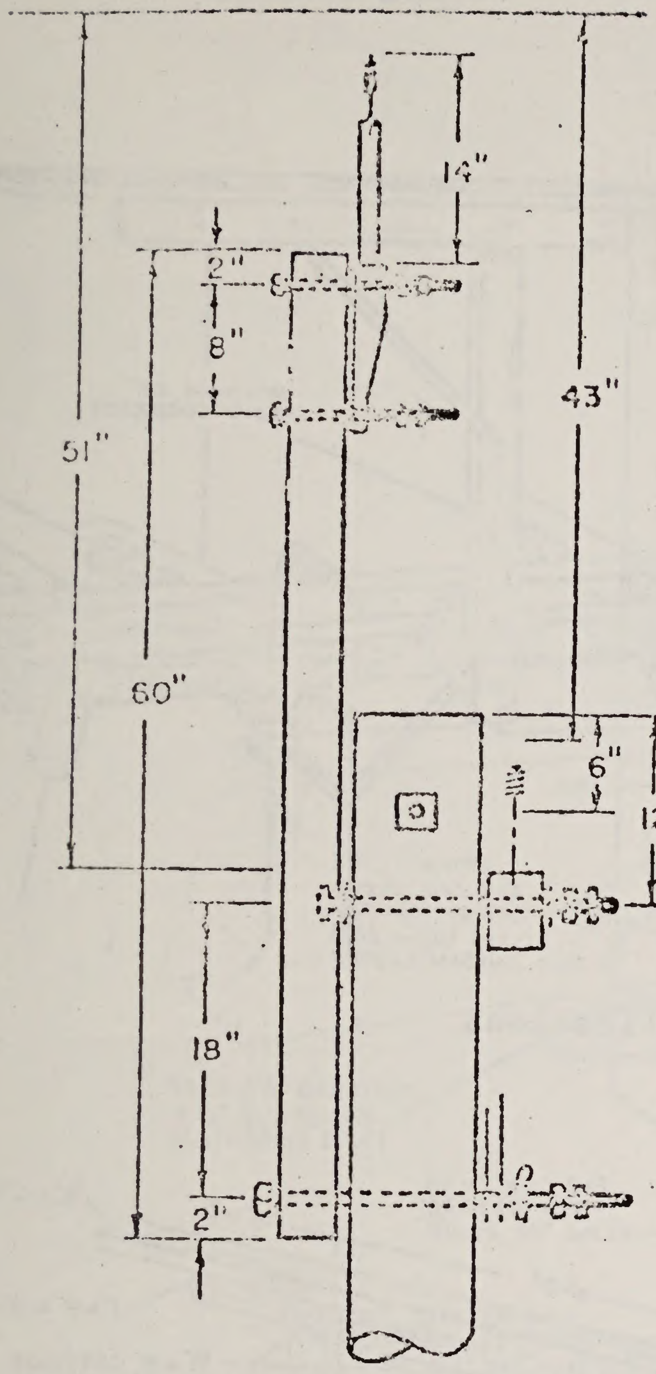
Approved for corrections
on preferred poles in
existing lines

Birds-of-Prey Consultant

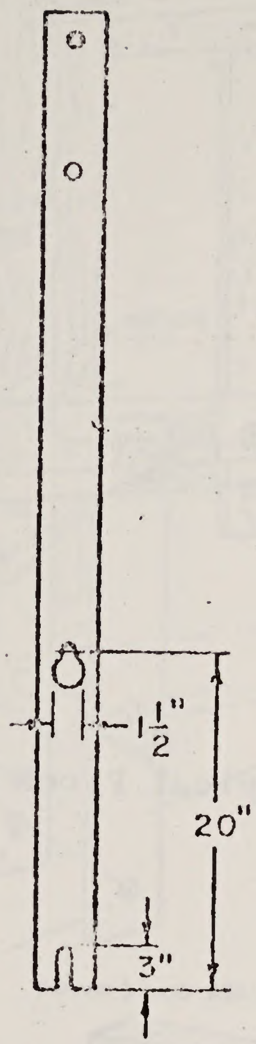


Approved type structure
to be installed in a
"Birds of Prey" area

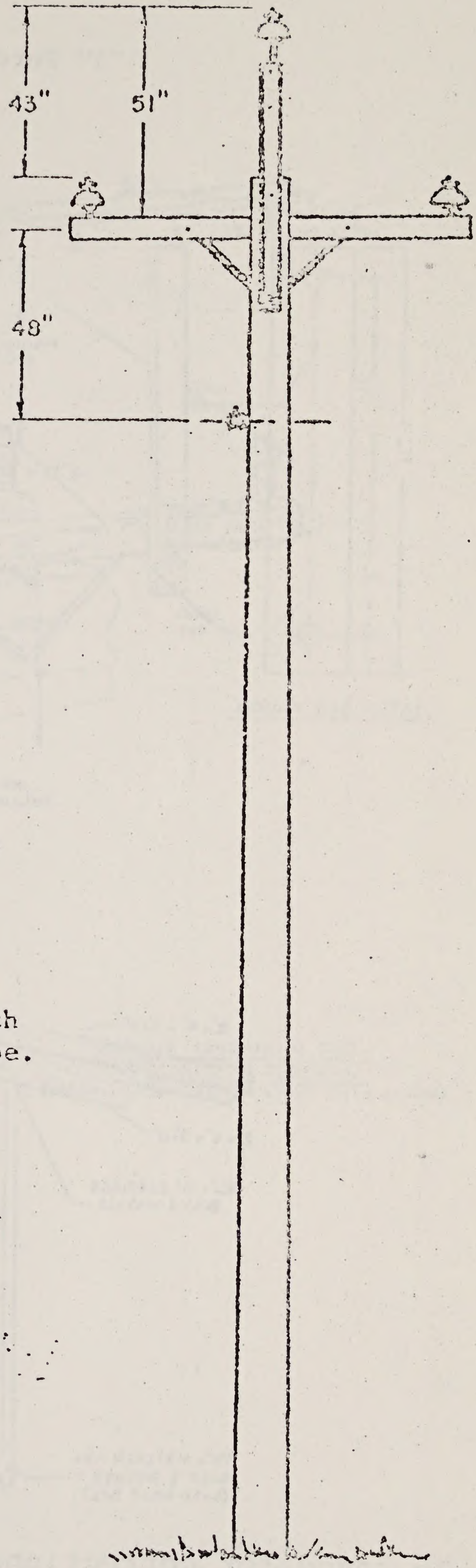
Birds-of-Prey Consultant



Assembly Detail



Fabricate from 3-inch galvanized steel pipe.



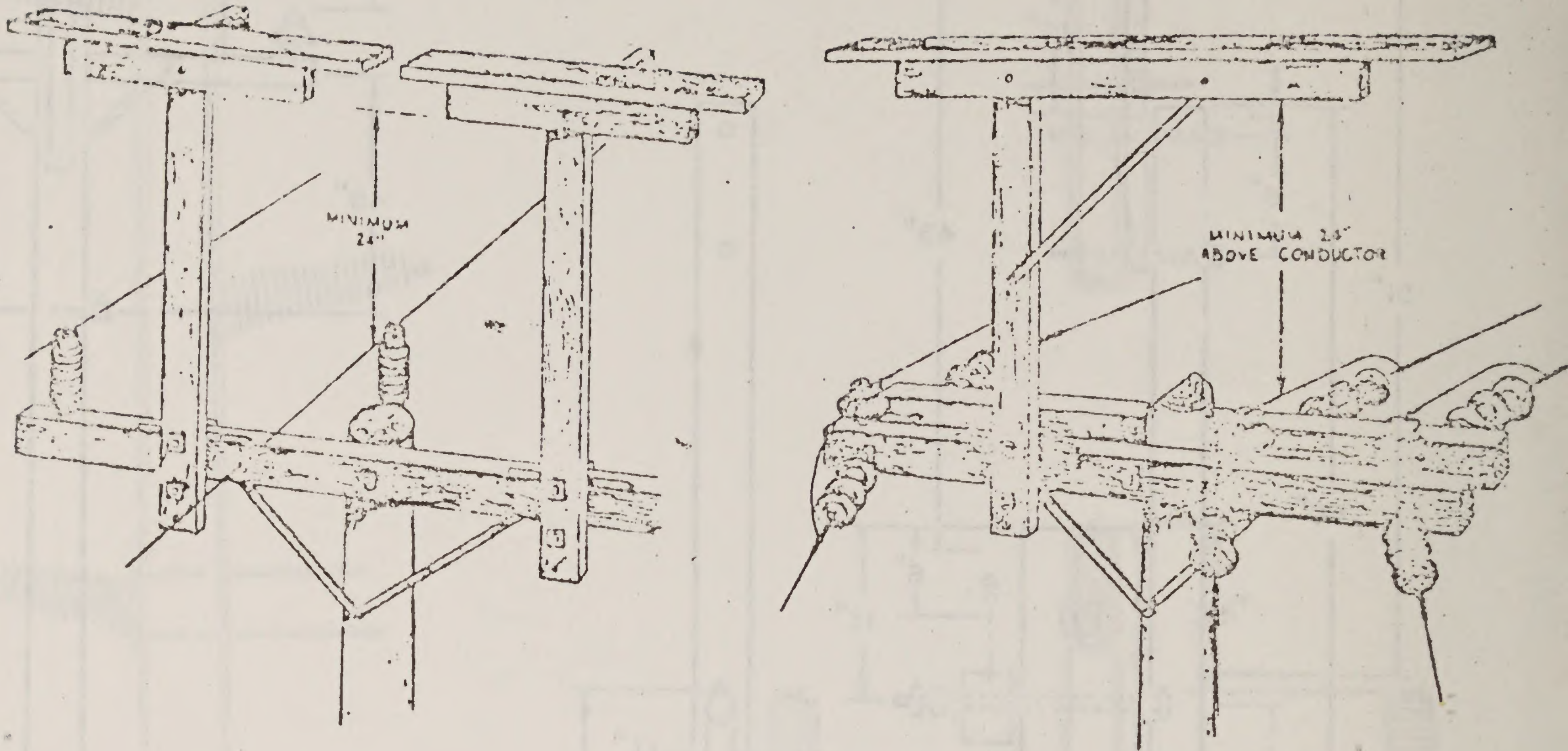
Center Phase Riser

pproved for corrections
n preferred poles in
xisting lines

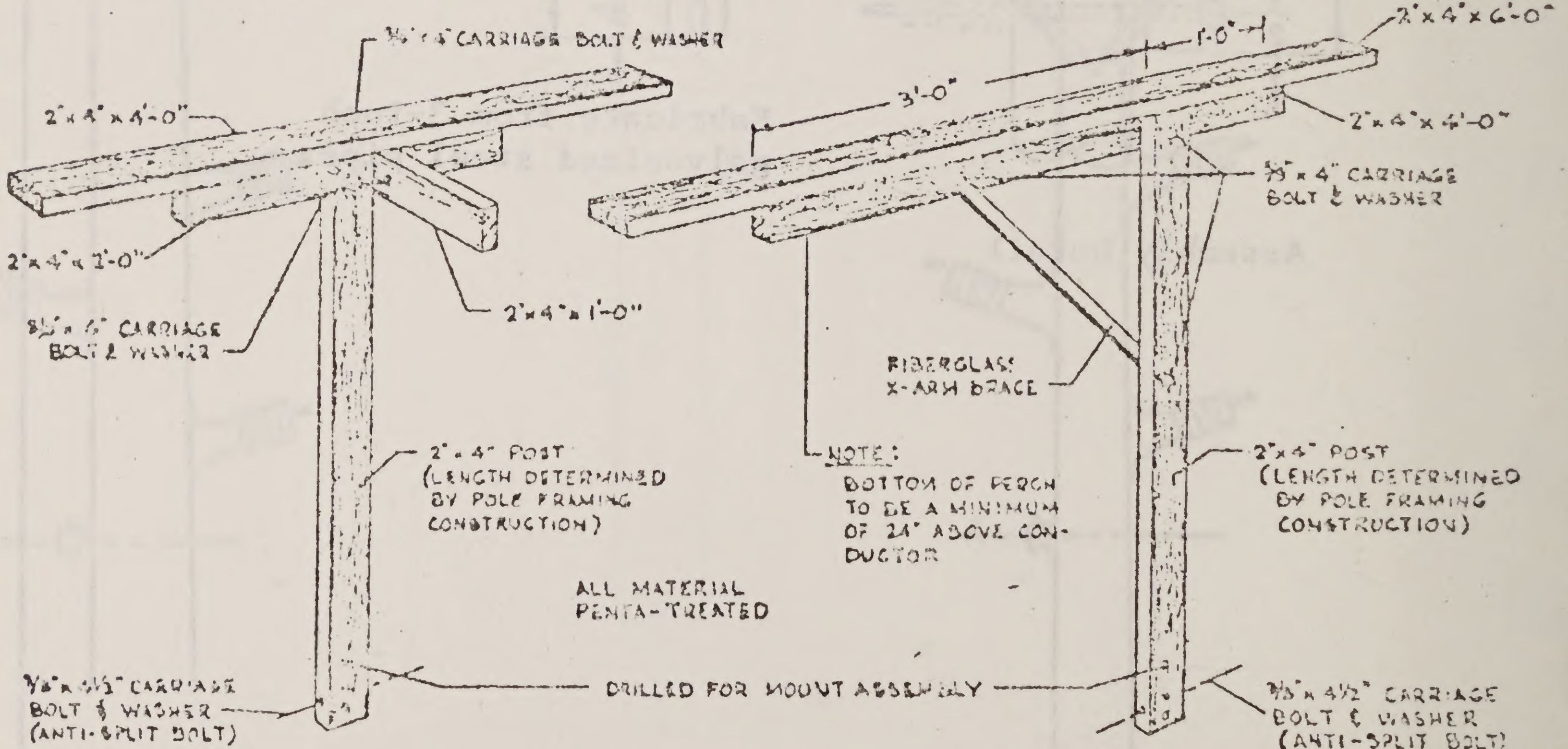
Birds-of-Prey Consultant

"T" Perch

Straight Perch



Typical Perch Applications

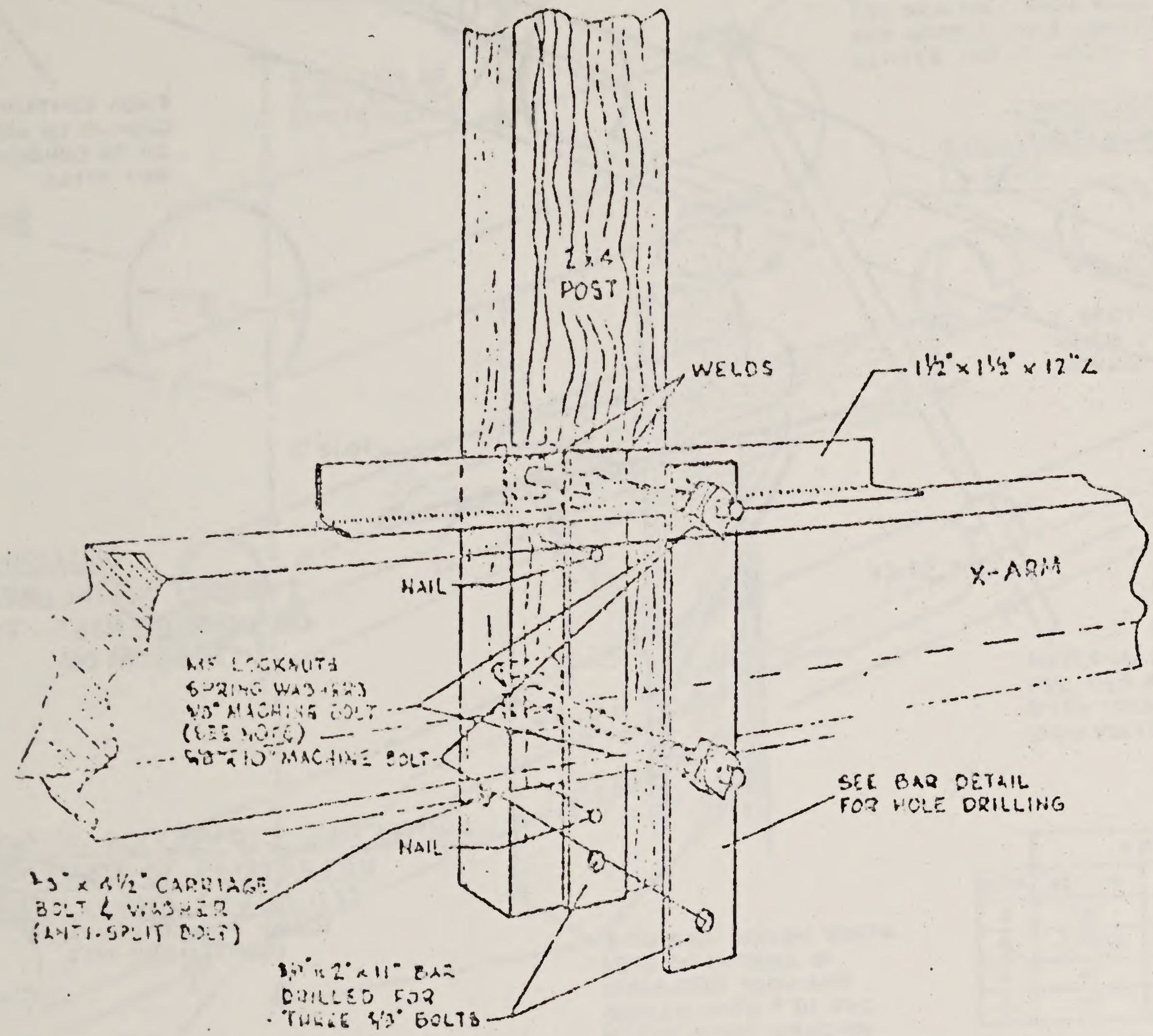


Approved for corrections
on preferred poles in
existing lines

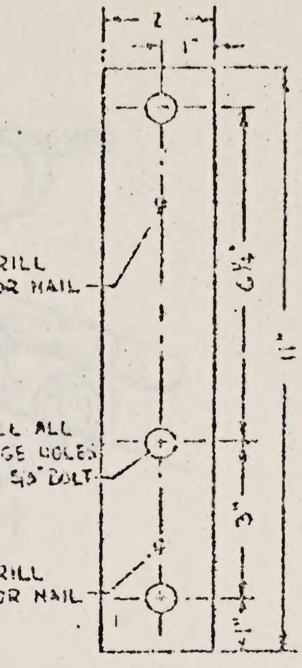
Perch Assembly Details

B-6

Right-of-Way Consultant



NOTE:
FOR LIGHT-DUTY X-ARM:
USE UPPER SET OF MOUNTING HOLES
USE 5/8" x 8" MACHINE BOLTS
FOR HEAVY-DUTY X-ARM:
USE LOWER SET OF MOUNTING HOLES
USE 5/8" x 10" MACHINE BOLTS



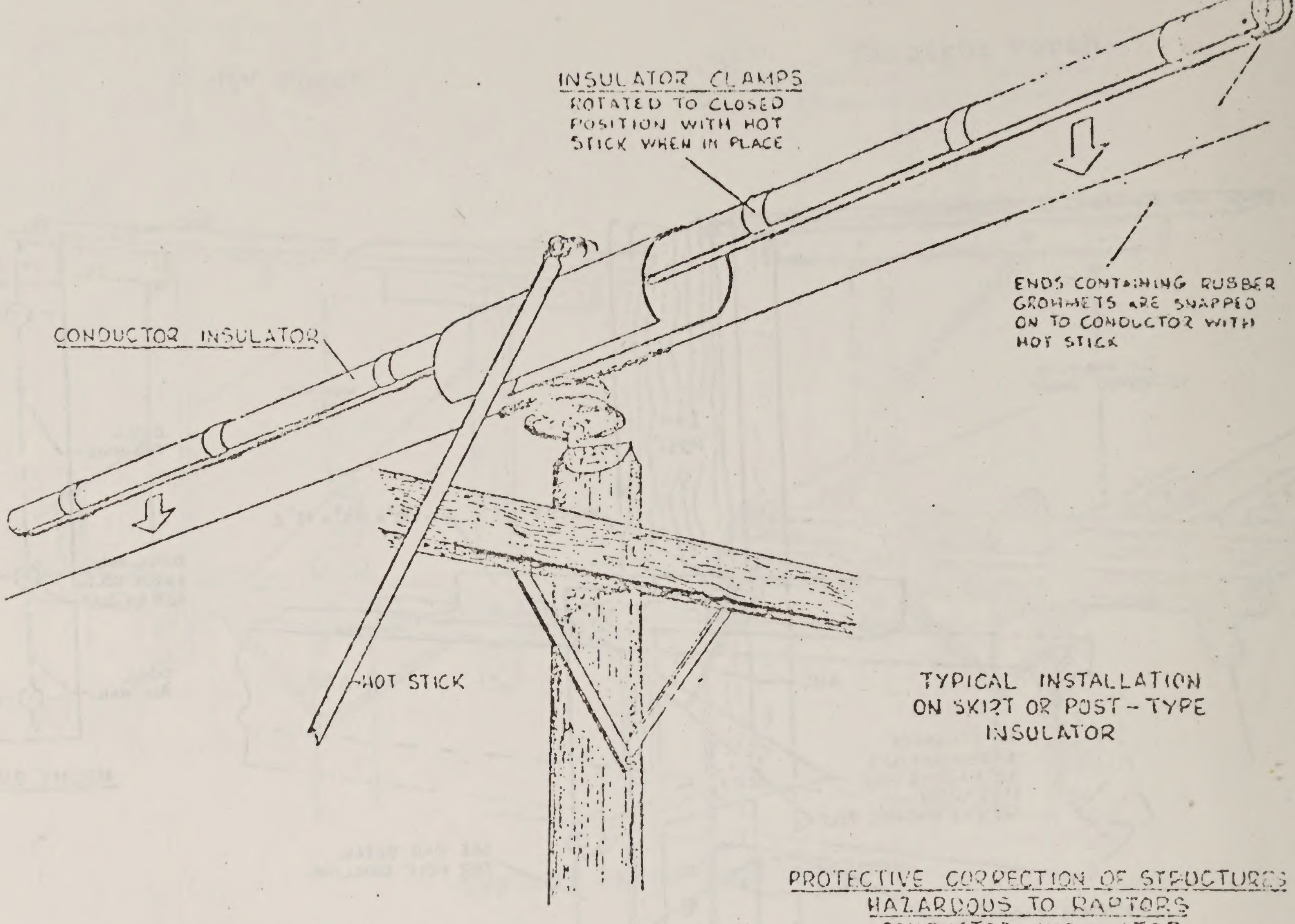
MOUNT BAR DETAIL

MOUNT ASSEMBLY FOR TYPES 1 & 2 PERCHES
(SHOWN MOUNTED ON LIGHT-DUTY X-ARM)

Approved for corrections
on preferred poles in
existing lines

Morlan W. Nelson

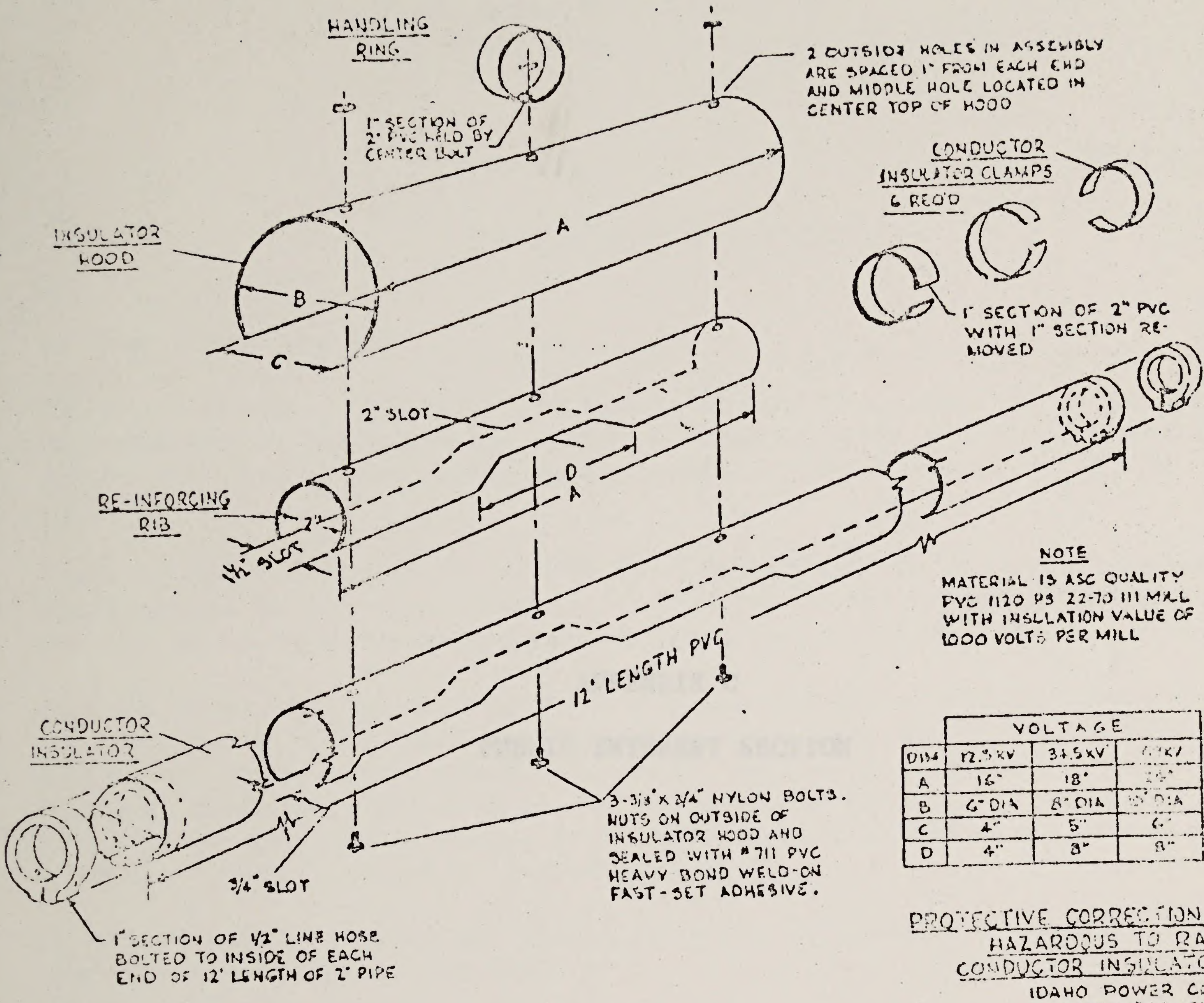
Birds of Prey Consultant



PROTECTIVE CORRECTION OF STRUCTURES
HAZARDOUS TO RAPTORS
CONDUCTOR INSULATOR
IDAHO POWER COMPANY
SEPTEMBER 1972

Approved for corrections
on preferred poles in
existing lines

Morlan W. Nelson
Birds-of-Prey Consultant



	VOLTAGE		
DIM	12.5 KV	34.5 KV	[illegible] KV
A	16"	18"	[illegible]
B	6" DIA	8" DIA	[illegible] DIA
C	4"	5"	6"
D	4"	8"	8"

PROTECTIVE CORRECTION OF STRUCTURES
HAZARDOUS TO RAPTORS
CONDUCTOR INSULATOR DETAILS
IDAHO POWER COMPANY
SEPTEMBER 1972

Approved for corrections
on preferred poles in
existing lines

Morlan W. Nelson

Birds-of-Prey Consultant

APPENDIX C

PUBLIC INTEREST SECTION

IN REPLY REFER TO

3200

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Burns District Office
74 South Alvord, Burns, Oregon 97720

JUL 29 1976

INVITATION TO PARTICIPATE

To Whom It May Concern:

The Burns District Office of the Bureau of Land Management is in the process of preparing an Environmental Analysis concerning the effect of proposed geothermal leasing and possible development on the areas shown on the enclosed maps.

These proposed lease areas include all non-competitive geothermal lease applications in the Burns District, a portion of the Ochoco National Forest and the Burns Butte known Geothermal Resource Area (KGRA)(see enclosed maps).

Factors which will be considered in the preparation of the Environmental Analysis Record (EAR) include impacts on air, land, water, terrestrial plants and animals, ecological processes, landscape character, socio-cultural interests, and others. If you have any comments on the effect of proposed geothermal leasing on the environment of this area, we would appreciate your comments by September 1, 1976.

If this letter generates sufficient interest and comment to justify a public meeting, a meeting will be held.

Send your comments to: L. C. Vosler, District Manager
Burns District Office
Bureau of Land Management
74 South Alvord
Burns, Oregon 97720

Sincerely,

L. Christian Vosler

L. Christian Vosler
District Manager

Interested Parties

Government Agencies

U. S. Fish and Wildlife Service
Division of Ecological Services
Portland Field Office
919 N. E. loth Ave.
Portland, OR 97232

Oregon Department of Fish and Wildlife
Southeast Region
Box 8
Hines, OR 97738

State Clearinghouse
Intergovernmental Relations Division
240 Cottage St., S.E.
Salem, OR 97310

Joseph Mazzoni, Manager
Malheur Wildlife Refuge
Box 113
Burns, OR 97720

U. S. Environmental Protection Agency
Region X
1200 Sixth Ave.
Seattle, Wash. 98101

U. S. Geological Survey
Area Geothermal Supervision
Conservation Division
345 Middlefield Rd.
Menlo Park, CA 94025

Bonneville Power Administration
Box 3621
Portland, OR 97208

Harney County Planning Commission
Harney County Courthouse
Burns, OR 97720

City of Burns
c/o Mayor Pete Clemena
Burns, OR 97720

City of Hines
c/o Mayor Candy Negus
Hines, OR 97738

Oregon Cooperative Wildlife Research Unit, USDI
Bioscience Building
Oregon State University
Corvallis, OR 97731

Regional Supervisor
Ochoco National Forest
U. S. Forest Service
Box 491
Prineville, OR 97754

U. S. Fish and Wildlife Service
Division of River Basin Studies
Port Office Bldg.
Burns, OR 97720

Don Rotell, District Ranger
Snow Mountain District
Ochoco National Forest
Box 188
Hines, OR 97738

Groups and Individuals

Oregon Environmental Council
c/o Larry Williams
2637 S.W. Water Ave.
Portland, OR 97201

Oregon High Desert Study Group
720 S.E. Park
Corvallis, OR 97330

Survival Center
Suite 1, EMU
Univ. Of Oregon
Eugene, OR 97403

Izack Walton League of America
Oregon Division
3300 S.W. Ridgewood Rd.
Portland, OR 97225

Nature Conservancy
Oregon Chapter
1234 N.W. 25th Ave.
Portland, OR 97210

Oregon Student Public Interest Research Group
408 S.W. 2nd St.
Portland, OR 97204

Sen. Robert W. Packwood
6327 New Senate Office Bldg.
Washington, D.C. 20510

Rep. Al Ullman
2410 Rayburn
House Office Bldg.
Washington, D.C. 20510

Terry Allen Kramer
730 Park Ave.
Apt. #1D
New York, N.Y. 10021

Robert B. Bunn
Box 939
Honolulu, Hawaii 96808

Charlea N. Huseman, Sr.
700 New Hampshire Ave., N.W.
Washington, D.C. 20037

Edward White
360 East 72nd St.
New York, N.Y. 10021

Earth Power Corp.
1550 Bay St., #137
San Francisco, CA 94123

LVO Corp
Box 2989
Tulsa OK 72101

Thermal Resources
39 Broadway 31st Floor
New York, N.Y. 10006

Sun Oil Co. (Deleware)
12850 Hillcrest Rd.
Dallas, TX 75320

John W. Hook
7315 Battle Creek Rd., S.E.
Salem, OR 97302

Honorable Dale White
Harney County Court
Burns, OR 97720

Times-Herald
Box 473
Burns, OR 97720

Richard Bowen, Consulting Geologist
852 N.W. Albemarle Terrace
Portland, OR 97210

Don Huel, Geologist
Oregon Dept. of Geology and Mineral Industries
2033 First St.
Baker, OR 97814

California-Pacific Utilities Co.
113 W. Washington
Burns, OR 97720

Harney Electric Cooperative
1326 Hines Blvd.
Burns, OR 97720

Denzell Ferguson
Malheur Environmental Field Station
Burns, OR 97720

Phillips Petroleum
Box 752
Del Mar, CA 92014

Energy Partners
44 Montgomery St., Rm. 4211
San Francisco, CA 94104

Pacific Energy Corp
44 Montgomery St.
Suite 2860
San Francisco, CA 94104

United States Department of the Interior

BONNEVILLE POWER ADMINISTRATION
P.O. BOX 3621, PORTLAND, OREGON 97208

OFFICE OF THE ADMINISTRATOR

Employee	Act	Info	Employee	Act	Info
DM			AM 1		
Adm.			AM 2		
			AM 3		
			AM 4		
Received AUG 30 1976			DISTRICT BURNS		
Resources			Opns		
All Emp.			File		

In reply refer to: AJ

August 25, 1976

Memorandum

To: L.C. Vosler, District Manager, Bureau of Land Management, Burns, Oregon

From: E. Willard, Assistant to the Administrator - Interagency Relations

Subject: Effect of proposed Geothermal Leasing -- Burns District, Oregon

In reference to your letter dated July 29, 1976, we find that the proposed leasing activity will have little or no effect on Bonneville Power Administration.

There is a BPA transmission line which could serve as an outlet for nominal amounts of any energy produced. The Redmond-Hampton-Harney 115-kV line seems to intersect the northern boundary of this area of interest three miles west of the Harney County line on the Deschutes-Lake County line and also the eastern boundary of the area three miles east of the Harney-Lake County line and three miles south of the extension of the Deschutes-Lake County line.

We would request that any leases provide that exploration activities be carried out in a manner that will not damage Federal facilities or cause interruptions in the service provided by Bonneville Power Administration.

In any power development program of this nature we would appreciate your agency coordinating with BPA so that power production could be smoothly integrated with the needs of the region.

Emmet E. Willard

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

Oregon High Desert Study Group

720 S.E. Park
Corvallis, Or. 97330

Aug. 24, 1976

COLLEEN GOODING
COORDINATOR

POST OFFICE BOX 25 • ST. PAUL, OREGON 97137

Received 1976 DISTRICT BURNS

Mr. Chris Vosler, District Manager
Bureau of Land Management
74 South Alvord
Burns, Or. 97720

Dear Mr. Vosler:

I am commenting for the OHDSG on the proposed geothermal leases in Burns Butte, the areas west and southeast of Harney Lake, and Diamond Craters. The OHDSG is most concerned about the proposed leases in Diamond Craters and those bordering the Harney Lake RNA proposed by the Bureau of Sport Fisheries and Wildlife.

We feel that Diamond Craters is a fascinating geological area. In April, the OHDSG saw Keyhole Crater, the spatter cone, a cinder crater and extensive areas of slab lava (some disturbed by people). In Keyhole Crater were excellent examples of pahoehoe lava. We hiked across lava flows to Malheur Maar, the lake inside a crater surrounded by rushes where yellow-headed blackbirds nested. In May, Colleen Gooding and I visited Diamond Craters again with the State Trails Council. We saw many large chunks of slab lava which made a hollow sound as we walked over it. Some of the lava formed tunnels and there was much pahoehoe lava. On both trips everyone was impressed by the variety of interesting lava formations. We didn't visit the craters named Diamond Craters, caves, or the very fragile lava formations mentioned by the BLM.

Wildlife were seen in Diamond Craters on these trips. On the Trails Council trip, we saw a small rattlesnake in the bottom of the spatter cone, great horned (?) owls nesting in a large crater, and bright yellow green frogs were observed on both trips.

We support your recommendation for a Research Natural Area and the proposed withdrawl for locatable minerals in Diamond Craters (16,656 acres), which would protect this area from people taking slab lava. Diamond Craters certainly has much potential for educational and scientific uses, because of the closeness to the Malheur Environmental Field Station. Recreational are possible in the area too. We support the Desert Trail route through Diamond Craters with consideration for fragile areas when planning the route. Another recreational use, auto road tour and short trails, is proposed by Joe Hessler. Our basic feeling is this proposal suggests too much development except for the brochure. With information about the area, people can easily visit the many craters from the county road and the access road.

Many of the unique features are in the proposed geothermal lease areas--Diamond Craters themselves, the maar, and from looking on the topographic map, there are certainly others. Since the proposed lease area can expand, leases could be applied for over the whole area. The potential of Diamond

Craters may not be high, because the leases are non-competitive and the area is not a Known Geothermal Resource Area. The closeness of the area to Malheur Wildlife Refuge should be considered in any leasing program. The noise and possible water pollution of geothermal plants would certainly be detrimental to the Wildlife Refuge. In view of the probable low quality of the area for geothermal, the high resource value as a Research Natural Area and part of the Desert Trail route, and the closeness to the Malheur Wildlife Refuge, we recommend no leases be granted in the Diamond Craters area. If the proposed leasing program proves controversial, we recommend that an Environmental Impact Statement be written. As we have noted before with the Alvord Basin Geothermal Leasing Program, decisions on whether to lease an area should consider other resource values before the leases are granted.

The OHDSG has not visited Harney Lake, but I have read the RNA proposal which emphasizes educational and scientific study, and not recreation. The proposed geothermal leases southeast of Harney Lake border the proposed RNA. Conflicts may arise here and perhaps leases should not be granted in sections adjacent to the proposed RNA on Malheur Wildlife Refuge lands.

We cannot comment specifically on the other lease areas. No roadless areas, or potential primitive, wilderness, or RNA are involved. Leasing of the areas northwest and northeast of Burns (especially Burns Butte) may show potential hot water for heating buildings in Burns and small scale agricultural/industrial uses, if not enough for power plants.

We appreciate this opportunity to comment on these proposed leases.

Sincerely,

Julie Ambler

Julie Ambler

cc: Murl Storms (State BLM Director), Gov. Straub, Sen. Mark Hatfield, Sen. Bob Packwood, Rep. Al Ullman, Bill Renwick II (Harney Co. Planning Commission, Russ Pengelly (Desert Trail Assoc.), Joe Mazzoni (Malheur Wildlife Refuge), Jim Montieth (Oregon Wilderness Coalition), Joe Walicki (Wilderness Society), Wayne Rifer (Nature Conservancy).

Received AUG 30 1976 DISTRICT BURNS
AM 3
AM 4
Resources Opns
All Emp. File

L.C. Vosler, District Manager
Burns District Office, B.L.M.
74 S. Alvord
Burns, OR 97720

Re: Environmental impacts of geothermal leasing, exploration, and development

Dear Chris,

Environmemtal impacts for each: leasing, exploration, and production are quite different, and more serious through progression toward development. The act of leasing has no environmental impact that I am aware of, other than perpetuating the current bid-rent structure for energy companies to take as capital investment or depletion write-offs. As such the impact is not generally , directly evident on the land.

Exploratory phases are more environmentally disruptive, and may differ in each of the areas, as the resource mix and their manifestations on each is unique to the areas. My comments will be directed to the generel. The actual test site, if donducted in the same manner as the shallow temperature gradient wills as those in the Alvord KGRA, would be relatively unbothered. Vegetation may suffer in the immediate test site, as alvord showed a strong incursion of Halogeton in the disturbed desert pavements. Most disruption would deal with access and traffic. Travel on existing roads would tend to be causing a great deal of dust during dry periods on minimum standard roads, and possible erosion and rutting during wet weather. If roads have to be built or improved to facilitate access for the proposed purpose, the damage would be potentially greater, as increased access would allow others to ingress and egress. Travel density seems to be most disruptive to wildlife, although the risk of livestock harassment is also greater. Any unique geologic of floristic sites may also be destroyed. But, by all means, keep all traffic on the roads, and not driving out through the brush and grass, or meadows and playas.

If geothermal energy were found to be developable, and if the decisions to invest in development were made, the impacts would be far greater, and should be dealt with separately, in environmental impact statements prepared for each. At this time, I could only relate my feelings about the landscape character, conflicts with livestock and wildlife uses, and the inability of the local mommunities and public facilities to accomodate a surge of new population.

The Diamond Crater site is extremely unique, primarily because of its geologic features - some of the most recent evidence of volcanic eruption in the West, with its related lavas and craters and tunnels. Its proximity to Steens Mountain and Malheur Wildlife Refuge are also extremely important, and any development within the area may jeopardize the unique resource values of the other two areas.

The West Harney Lake site and the Weed Lake Flat/Jackass Mountain complexes are also unique, and are close to the Wildlife

Refuge. The proximity may also jeopardize some wildlife values near or on the Refuge. Further, Harney Lake and Weed Lake Flat are unique in their ecologic complexes. The alkaline playa ecotome is one that has not been studied adequately, expecially for its importance and stability. The two playas also, independent of the Refuge, provide unique wildlife values. If any development ist to take place in these areas, or any exploration, all work should definitely be out of the playa.

I appreciate the opportunity to respond, and would appreciate being kept up to date in the processes on these sites, and others.

Respectfully,

William R. Renwick

William R. Renwick II
643 S. Juntura
Burns, OR 97720

ROBERT W. STRAUB
GOVERNOR

Department of Transportation
PARKS AND RECREATION BRANCH
525 TRADE STREET S.E., SALEM, OREGON 97310

August 16, 1976

Ms. Ruth McGilvra, Archeologist
Bureau of Land Management
74 S. Alvord St.
Burns, Oregon 97720

Dear Ruth:

A search of our files and those of the University of Oregon has turned up the following information. The Willow Creek, Burns Butte and Prater Creek areas have not been professionally surveyed but should be. These areas have been potted and petroglyphs are also known to exist in the area.

As far as the other areas are concerned, none of them have been completely surveyed, but some sites have been mapped in the following areas: Sec. 4, 14, 24, 25, and 35 of Township 29 S, Range 31 E. There are actually two sites in Sec. 14. I realize that some of this area is outside of the actual leasing areas, but the fact that only partial surveys have turned up an abundance of material indicates the need for professional surveys of the cultural resources for all areas where ground-disturbing activities are to take place.

I believe that I sent along to you a Xerox copy of Statewide Inventory historical sites. If you do need another copy, just give me a call and I'll get it in the mail to you.

Bob Sutton and I passed through Burns some three weeks back on a Friday evening and attempted to call you. Since there was no answer, we assumed you were "out on the town".

Sincerely,
Edward T. Long (Ted)

Edward T. Long
Historic Preservation Archeologist
State Historic Preservation Office

EL:ko

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE

Intergovernmental Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Leslie Lehmann, Coordinator Ph: 378-3732

STATE A-95 REVIEW CONCLUSIONS

Received AUG 2 1976 DISTRICT BURNS

APPLICANT: Bureau of Land Management

PROJECT TITLE: E.A.R. Geothermal Lease

DATE: 8/25/76

The state has reviewed your project and reached the following conclusions:

[XX] No significant conflict with the plans, policies or programs of state government have been identified ~~and your proposal is endorsed as presented~~.

[XX] Relevant comments of state agencies are attached and should be considered in the final design of your proposal.

[ ] Potential conflicts with the plans and programs of the state agency(s) have been satisfactorily resolved. No significant issues remain.

[ ] Significant conflicts with the plans, policies or programs of state government have been identified and remain unresolved. The final proposal has been reviewed and the final comments and recommendations of the state are attached.

NOTICE TO FEDERAL AGENCY

The following is the officially assigned State Identifier Number:

7607 5 1230

This number should be used on all correspondence and particularly on SF 240 as required by OMB A-98.

PNRS #2

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE

BLM Geothermal Leasing Program (GLP)

Intergovernmental Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Leslie Lehmann, Coordinator Phone: 378-3732

AUG 4 1976

PNRS STATE REVIEW

Project #: 7607 5 1230 Due Date: AUG 20 1976

To Agency Addressed: If you intend to comment but cannot respond by the return date, please notify us immediately. If no response is received by the due date, it will be assumed that you have no comment and the file will be closed.

PROGRAM REVIEW AND COMMENT

To State Clearinghouse: We have reviewed the subject Notice and have reached the following conclusions on its relationship to our plans and programs:

( ) It has no adverse effect.

( ) We have no comment.

( ) Effects, although measurable, would be acceptable.

( ) It has adverse effects.

( ) We are interested but require more information to evaluate the proposal.

( ) Please coordinate the implementation of the proposal with us.

(✓) Additional comments for project improvement. (Attach if necessary)

REMARKS (Please type or print legibly)

Transportation should be strongly considered in the EAR as part of the socio-cultural interests.

Agency Burco By Wm L. Hall
Planning Section

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE

DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT

AUG - 3 1976

SALEM

Intergovernmental Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Leslie Lehmann, Coordinator Phone: 378-3732

PNRS STATE REVIEW

Project #: 7607 5 1230 Due Date: AUG 20 1976

To Agency Addressed: If you intend to comment but cannot respond by the return date, please notify us immediately. If no response is received by the due date, it will be assumed that you have no comment and the file will be closed.

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( ) We are interested but require more information to evaluate the proposal.

( ) Please coordinate the implementation of the proposal with us.

(X) Additional comments for project improvement. (Attach if necessary)

- - - - - - - - - - - -

Project # 7607-5-1230 | REMARKS (Please type or print legibly)

The EAR should consider the possibility of full field development and the resulting social and economic impacts on the area. An analysis of these types of impacts should include the participation of the county local officials and coordination with local planning departments.

8/24/76

Agency LCDC By Dennm Hopp for John Grkhofer

71

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE

LOCAL GOVERNMENT RELATIONS DIV
AUG 12 1976

RECEIVED
AUG 5 -

Intergovernmental Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Leslie Lehmann, Coordinator Phone: 378-3732

PNRS STATE REVIEW

Project #: 7607 5 1230 Due Date: AUG 20 1976

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( ) Please coordinate the implementation of the proposal with us.

( ) Additional comments for project improvement. (Attach if necessary)

- - - - - - - - - - -

REMARKS (Please type or print legibly)

We have submitted a report to the Burns District Headquarter describing geothermal potential of the area, general geology and expected impact of geothermal development.

Agency Geology By V.C. Newton

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE

Intergovernmental Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Leslie Lehmann, Coordinator Phone: 378-3732

AUG 1 6 1976

PNRS STATE REVIEW

Project #: 7607 5 1230 Due Date: AUG 20 1976

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(X) Please coordinate the implementation of the proposal with us.

( ) Additional comments for project improvement. (Attach if necessary)

- - - - - - - - - - -

REMARKS (Please type or print legibly)

Initial exploration activities should be a minor harassment problem in these areas based on what we have seen so far. We request that a minimum of new access roads to drilling sites be constructed, and any new roads be kept to minimum standards. Vegetative cover in all areas should be disturbed as little as possible, including revegetation of disturbed areas after exploration.

Actual development at any one of these sites might bear some further, serious evaluation. There is game and/or non-game use at all of these sites. The Willow Creek, Burns Butte and Prater Creek areas are the only ones partially encompassing or bordering on a deer winter range. Information on the Willow Creek area was covered in our comments on the gas and oil leasing in this same area.

Agency Fish & Wildlife By Norman Behrens
ENVIRONMENTAL MANAGEMENT SECTION 8/17/76.

Employee	Act	Info	Employee	Act.	Info
DM			AM 1		
Adm.			AM 2		
			AM 3		
			AM 4		

Receive NOV 29 1976 DISTRICT BURNS

Resources		Cons		
Lands				
Rec.	DEV			
All Emp.		File		

Chris Vosler
District Manager
Burns District BLM
74 So. Alvord St.
Burns, Oregon 97720

Mr. Vosler,

I am writing in support of the proposal to designate Diamond Craters Roadless Area as a Research Natural Area. I am opposed to any geothermal development, in this area and feel that before any development can be considered, a NEPA Environmental Impact Statement must be prepared.

This area is truly unique and interesting and should be preserved.

With respect for the land,

Robyn Ames
744 So. 5. Ave W
Missoula, Montana 59801

APPENDIX D

WILDLIFE LIST

D

James Vosler
District Manager
Burns District BLM
74 So. Alvord St.
Burns, Oregon 97720

Mr. Vosler,

I am writing in support of the proposal to designate "Diamond Craters" Roadless Area as a Research Natural Area. I am opposed to any mechanized developments in this area and feel that before any development can be considered, a NEPA Environmental Impact Statement must be prepared.

This area is truly unique and interesting and should be protected.

With respect for the land,

Robyn Ames
[illegible]
Missoula, Montana 59801

The proposed lease area was divided into two areas, called "Life Zones", due to large differences in species found in these two areas.

The Conifer Life Zone includes the Ponderosa pine plant communities.

The High Desert Life Zone includes the other plant communities in the area.

BIRDS

Birds that are extremely rare (i.e. one sighting in 30 years) in Harney County were omitted.

Check-List Key

Abundance

VC	Very common; 50 or more birds per day/observer/area.
C	Common; 10-49 birds per day/observer/area.
U	Uncommon; 0-9 birds per day/observer/area.
R	Rare; 5 or less birds per year/observer/area.
VR	Very rare; 5 or less birds per year/all observers/state.
O	Occasional; not seen every year, but occurs regularly.
A	Accidental; 5 or less total records for the state or area.
I	Irregular; abundance and/or occurrence fluctuates greatly from year to year.

NAME	PREFERRED HABITAT	LIFE ZONE HIGH DESERT	LIFE ZONE CONIFER
Common Loon (Givia immer)	Aquatic	R	U
Horned Grebe (Podiceps suritus)	Aquatic	R	?
Earred Grebe (Podiceps caspicus)	Aquatic	VC	R
Western Grebe (Aechmophorus occidentalis)	Aquatic	VC	?
Pied-billed Grebe (Podilymbus podiceps)	Aquatic	C	U
White Pelican (Pelecanus erthrorhynchos)	Aquatic	VC	
Double-crested Cormorant (Phalacrocorax auritus)	Aquatic	C	C
Great Blue Heron (Ardea herodias)	Aquatic	C	U
Snowy Egret (Leucophoyx thula)	Aquatic	U	
Great Egret (Casmerodius albus)	Aquatic	C	
Black-crowned Night Heron (Nycticorzx mycticorax)	Aquatic	C	C
Least Bittern (Ixobrycus exilis)	Aquatic	O	?
American Bittern (Botarurus lentignosus)	Aquatic	U	R
White-faced Ibis (Plegadis chihi)	Aquatic	U	
Whistling Swan (Olor columbianus)	Aquatic	C	C
Trumpter Swan (Olor Buccinator)	Aquatic	U	
Canada Goose (Branta canadensis)	Aquatic, fields	VC	C
White-fronted Goose (Anser albifrons)	Aquatic	C	C
Snow Goose (Chen caerulescens) (Includes Blue Goose)	Aquatic	VC	
Ross Goose (Chen rossii)	Aquatic	R	
Mallard (Anas platyrhynchos)	Aquatic	VC	C
Gadwall (Anas strepera)	Aquatic	VC	U
Pintail (Anas acuta)	Aquatic	VC	VC
Green-winged Teal (Anas crecca)	Aquatic	VC	C
Blue-winged Teal (Anas discors)	Aquatic	U	
Connamon Teal (Anas cyanoptera)	Aquatic	VC	C
European Wigeon (Anas penelope)	Aquatic	O	
American Wigeon (Anas americana)	Aquatic	VC	
Northern Shoveler (Anas clypeata)	Aquatic	C	
Wood Duck (Aix sponsa)	Aquatic	U	U
Redhead (aythya americana)	Aquatic	VC	U
Ring-necked Duck (Aythya collaris)	Aquatic	U	
Canvasback (Aythya valisineria)	Aquatic	VC	?
Lesser Scaup (Aythya affinis)	Aquatic	C	?
Common Goldeneye (Bucephala clangula)	Aquatic	U	U
Barrows Goldeneye (Buchephala islandica)	Aquatic	R	U

NAME	PREFERRED HABITAT	LIFE ZONE HIGH DESERT	CONIFER
Bufflehead (Buchephala albeola)	Aquatic	U	?
Ruddy Duck (Oxyura jamaicensis)	Aquatic	VC	?
Hooded Merganser (Lpphodytes cucullatus)	Aquatic	U	
Common Merganser (Mergus merganser)	Aquatic	U	
Turkey Volture (Cathartes aura)	Farmlands, rangelands	C	C
Goshawk (Accipiter gentilis)	Forests	O	R
Sharp-shinned Hawk (Accipiter striatus)	Forests	O	U
Coopers Hawk (Accipiter cooperii)	Forests, Canyons	R	U
Red-tailed Hawk (Buteo jamaicensis)	Forests, farmlands	U	U
Swainson's Hawk (Buteo swainsonii)	Dry plains, foothills	U	?
Rough-legged Hawk (Buteo lagopus)	Plains, marshes	C	?
Ferruginous Hawk (Buteo regalis)	Rangelands	O	
Golden Eagle (Aquila chryseaetos)	Mountains, plains	U	U
Bald Eagle - Northern (Haliaeetus leucocephalus)	Rangelands	U	U
Marsh Hawk (Circus cyaneus)	Marshes, rangeland	C	?
Osprey (Pandion haliaetus)	Aquatic	U	
Gyrfalcon (Falco rusticolus)	Open mountains - Steens Mt., Conifers	R	R
Prairie Falcon (Falco mexicanus)	Prairies, deserts	U	
Peregrine Falcon (Falco peregrinus)	Open country	R	
Merlin (Falco columbarius)	Woodlands	R	R
American Kestrel (Falco sparverius) (Sparrow Hawk)	Open country	C	C
Blue Grouse (Dendragapus obscurus)	Wooded slopes		C
Ruffed Grouse (Bonasa umbellus)	Mixed or deciduous woods		U
Sage Grouse (Centrocerus urophasianus)	Sagebrush	C	R
California Quail (Lophortyx californicus)	Woodlands, brush	C	C
Mountain quail (Oreortyx pictus)	Woodlands, forests	U	U
Ring-necked Pheasant (Phasianus colchicus)	Farmlands	U	A
Chukar (Alectoris chukar)	Rocky sagebrush, grassland	VC	U
Gray Partridge-Hun (Peridix peridix)	Sagebrush	R	U
Greater Sandhill Crane (Grus canadensistabida)	Fields, marshes	VC	U
Lesser Sandhill Crane (Grus Canadensis candensis)	Fields, marshes	VC	
Virginia Rail (Rallus limicola)	Marshes	U	
Sora (Porzana carolina)	Marshes	U	
American Coot (Fulica americana)	Aquatic	VC	VC

NAME	PREFERRED HABITAT	LIFE ZONE HIGH DESERT	CONIFER
Semipalmated Plover (Charadrius semipalmatus)	Coastal	R	
Killdeer (Charadrius vociferus)	Fields, shorelines, meadows	C	C
Common Snipe (Capella gallinago)	Marshes, wet meadows	C	U
Long-billed Curlew (Numenius americanus)	Meadows	C	
Spotted Sandpiper (Actitis macularia)	Aquatic	U	C
Solitary Sandpiper (Tringia solitaria)	Aquatic	O	
Willet (Catoptrophorus semipalmatus)	Marshes, beaches	U	
Greater Yellowlegs (Tringa melanoleucus)	Marshes, mudflats	U	U
Lesser Yellowlegs (Tringa flavipes)	Marshes, mudflats	R	?
Red Knot (Calidris canulus)	Coastal	A	
Pectoral Sandpiper (Calidris melanotos)	Tidal flats, mudflats	R	R
Baird's Sandpiper (Calidris bairdii)	Mudflats	U	A
Least Sandpiper (Calidris minutilla)	Tidal flats, marshes	U	
Dunlin (Calidris alpina)	Tidal flats, beaches	R	
Long-billed Dowitcher (Limnodromus scolopaceus)	Mudflats	VC	
Western Sandpiper (Calidris mauri)	Mudflats, beaches	C	U
Marbled Godwit (Limosa fedoa)	Mudflats, beaches	R	
Sanderling (Calidris alba)	Sandy beaches	O	
American Avocet (Recurvirostra americana)	Marshes	VC	R
Black-necked Stilt (Himantopus mexicanus)	Marshes	C	
Wilson's Phalarope (Steganopus tricolor)	Marshes	C	
Northern Phalarope (Lobipes lebatus)	Open Ocean	C	
California Gull (Larus californicus)	Aquatic	C	C
Ring-billed Gull (Larus delawarensis)	Aquatic	VC	U
Franklins Gull (Larus pipixcan)	Aquatic	U	
Bonaparte's Gull (Larus philadelphia)	Aquatic	R	
Forester's Tern (Sterna forsteri)	Aquatic	C	
Caspian Tern (Hydroprogne caspis)	Aquatic	U	
Black Tern (Childonias niger)	Aquatic	C	
Band-tailed Pigeon (Columba fasciata)	Coast conifers	A	A
Rock Dove (Domestic pigeon) (Columba livia)	Urban and farmlands	C	C
Mourning Dove (Zenaida macroura)	Farmlands, rangelands	VC	C
Yellow-billed Cuckoo (Coccyzus americanus)	Riverbottoms	A	
Barn Owl (Tyto alba)	Abandoned buildings	R	U
Screech Owl (Otus asia)	Deciduous woods	R	U
Flammulated Owl (Otus flammeolus)	Ponderosa pine	A	VR

NAME	PREFERRED HABITAT	LIFE ZONE HIGH DESERT	LIFE ZONE CONIFER
Great Horned Owl (Bubo virginianus)	All areas	C	U
Snowy Owl (Nyctea scandiaca)	Dunes, fields	I	I
Pygmy Owl (Glaucindium gnoma)	All areas	C	U
Burrowing Owl (Speotyto cunicularia)	Dry grasslands	U	
Long-earred Owl (Asio otus)	Mixed woods	U	R
Short-earred Owl (Asio flammeus)	Fields, marshes	U	U
Saw-whet Owl (Aegolius acadicus)	Mixed woods	VR	R
Poor-will (Phalaenoptilus nuttallii)	Rock scarps	U	R
Common Nighthawk (Chordeiles minor)	All open lands	VC	U
Vaux's Swift (Chaetura vauxi)	Mixed woods	R	C
White-throated Swift (Aeronautes Saxatalis)	Rock Scarps	R	R
Rufous Hummingbird (Selasphorus rufus)	Mixed woods, fields	U	C
Calliope Hummingbird (Stellula calliope)	Mountain meadows	R	U
Belted Kingfisher (Megaceryle alcyon)	Aquatic	U	U
Common Flicker (Colaptes auratus)	Mixed woods, sagebrush, conifers		R
Pileated Woodpecker (Dryocopus pileatus)	Conifers		R
Lewis' Woodpecker (Asyndesmus lewis)	All woods	U	U
Yellow-bellied Sapsucker (Sphyrapicus varius)	Mixed woods	U	U
Williamson's Sapsucker (Sphyrapicus thyroideus)	Ponderosa pine	R	U
Hairy Woodpecker (Dendrocopus villosus)	Mixed woods, conifers	R	U
Downy Woodpeckeer (Dendrocopus pubescens)	Mixed woods, deciduous	U	U
White-headed Woodpecker (Denrocopus albolarvatus)	Ponderosa pine		U
Black-backed Three-toed Woodpecker (Picoides arcticus)	Lodgepole pine		R
Northern Three-toed Woodpecker (Picoides tridactylus)	Lodgepole pine burns		R
Eastern Kingbird (Tyrannus tyrannus)	River Valleys	U	U
Western Kingbird (Tyrannus verticalis)	Ranches	U	U
Ash-throated Flycatcher (Myiarchus cinerascens)	Juniper, sagebrush	U	R
Say's Phoebe (Sayornis saya)	Ranches, sagebrush	U	U
Willow Flycatcher (Empidonax traillii)	Wooded streams	U	U
Hammond's Flycatcher (Empidonax hammondii)	Conifers	R	U
Dusky Flycatcher (Empidonax oberholseri)	Scrub, hillsides	U	U
Gray Flycatcher (Empidonax wrightii)	Sagebrush, junipers	C	
Western Flycatcher (Empidonax difficilis)	Deciduous woods	R	

NAME	PREFERRED HABITAT	LIFE ZONE HIGH DESERT	CONIFER
Western Wood Peewee (Contopus sordindulos)	Conifers, all woods	U	C
Olive-sided Flycatcher (Nuttallornis borealis)	Mixed woods	R	U
Horned Lark (Eremophila alpestris)	Open fields, rangelands, alpine	VC	U
Violet-green Swallow (Tachycineta thalassina)	Around water	C	U
Tree Swallow (Iridoprocne bicolor)	River, mountain lakes	VC	U
Bank Swallow (Riparia riparia)	Around water	U	U
Rough-winged Swallow (Stelgidopterys ruficollis)	Around water	U	U
Barn Swallow (Hirundo rustica)	Around water	C	C
Cliff Swallow (Petrochelidon pyrrohonota)	Rock scarps, buildings	VC	C
Gray Jay (Perisoreus canadensis)	Mountain conifers	R	U
Steller's Jay (Cyanocitta stelleri)	Mixed conifers	R	U
Black-billed Magpie (Pica pica)	Rangelands	C	U
Common Raven (Corvus corax)	Rangelands, rock scarps	C	C
Common Crow (Corvus brachyrhynchos)	Open woods, farms	U	C
Pinon Jay (Gymnorhinus cyanocephala)	Juniper, Ponderosa pine	R-I	C-I
Clark's Nutcracker (Nudifraga columbiana)	Timberline conifers	R	U
Black-capped Chickadee (Parus atricapillus)	Deciduous woods	R	U
Mountain Chickadee (Parus gambeli)	Conifers, junipers	R	C
Plain Titmouse)Parus inornatus)	Chaparral	A	
Bushtit (Psaltriparus minimus)	Deciduous woods	U	
White-breasted Nuthatch (Sitta corolinensis)	Deciduous, mixed woods	R	U
Red-breasted Nuthatch (Sitta canadensis)	Conifers, mixed woods	U	U
Pygmy Nuthatch (Sitta Pygmaea)	Ponderosa pine		C
Brown Creeper (Certhis familiaris)	Conifers, mixed woods	R	U
Dipper (Cinclus mixicanus)	Mountain streams	R	U
House Wren (Troglodytes oedon)	Deciduous woods, brush	U	U
Winter Wren (Troglodytes troglodytes)	Dense conifers	R	C
Long-billed Marsh Wren (Telmatodytes palustris)	Marshes	C	U
Canon Wren (Catherpes mixicanus)	Rims and canyons	U	U
Rock Wren (Salipinates obsoletus)	Rims and boulders	U	C
Mockingbird (Mimus polyglottos)	Ranches, urban areas	R	
Catbird (Dumetella carolinensis)	Thickets, brush	R	U
Sage Thrasher (Oreoscoptes montanus)	Sagebrush	U	R
American Robin (Turdus migratorius)	Urban fields	VC	VC
Varied Thrush (Ixoreus maevius)	Conifers, mixed woods	R	U
Hermit Thrush (Catharus guttata)	Deciduous woods, conifers	U	C

NAME	PREFERRED HABITAT	LIFE ZONE HIGH DESERT	LIFE ZONE CONIFERS
Swainson's Thrush (Catharus ustulata)	Conifers, mixed woods	R	C
Western Bluebird (Sialia mexicana)	Open woods	R	U
Mountain Bluebrid (Sialia currocoides)	Sagebrush, junipers	C	C
Townsends Solitaire (Myadestes townsendi)	Conifers, juniper	C	U
Golden-crowned Kinglet (Regulus satrapa)	Conifers, sagebrush	R	C
Ruby-crowned Kinglet (Regulus calaendula)	Mixed woods	U	U
Water Pipet (Anthus spinoletta)	Fields, mountains	VC	U
Bohemian Waxwing (Bombycilla garrula)	Deciduous woods, juniper	I	I
Cedar Waxwing (Bombycilla cedrorum)	Open woods, near water	U	C
Northern Shrike (Lanius excubitor)	Juniper, sagebrush, fields	R	U
Logger Shirike (Lunius ludovicianus)	Juniper, sagebrush	C	U
Starling (Sturnus vulgaris)	Open fields, farms	C	C
Solitary Vireo (Vireo solitarius)	Deciduous woods	U	U
Warbling Vireo (Vireo gilvus)	Deciduous woods	U	U
Balck & White Warbler (Mniotilta varia)	Deciduous woods	A	
Tennessee Warbler (Vermivora peregrina)	Stream bottoms	VR	
Orange-crowned Warbler (Vermivora celata)	Brush	U	U
Nashville Warbler (Vermivora ruficapilla)	Oak, brushy slopes	R	U
Yellow Warbler (Dendroica petechia)	Stream bottoms	C	U
Yellow-rumped Warbler (Dendrocia coronata)	Stream bottoms	U	U
Black-throated Gray Warbler (Dendroica nigrescens)	Junipers, mixed woods	U	R
Townsend's Warbler (Dendroica townsendi)	Conifers	U	U
Ovenbird (Servivrus aurocapillus)	Stream bottoms	VR	
MacGillivray's Warbler (Oporonis tolmiei)	Mixed woods, brush	U	C
Common Yellow-throat (Geothlypis trichas)	Marshes	C	U
Yellow-breasted Chat (Icteria virens)	Moist thickets	U	U
Wilson's Warbler (Wilsonia pusilla)	Deciduous woods	C	C
House Sparrow (Passer domesticus)	Urban, farms	C	C
Bobolink (Dolichonyx oryzivorus)	Grasslands, fields	U	U
Western Meadowlark (Sturnella neglecta)	Fields, sagebrush	VC	C
Yellow-headed Blackbird (Xanthocephalus xanthocephalus)	Marshes	VC	U
Red-winged Blackbird (Agelaius phoeniceus)	Marshes	VC	C
Northern Oriole (Icterus galbula)	Shade trees, irrigated valleys	U	U
Brewers Blackbird (Euphagus cyanocephalus)	Fields, farms	VC	VC

NAME	PREFERRED HABITAT	LIFE ZONE HIGH DESERT	CONIFERS
Brown-headed Cowbird (Molothrus ater)	Fields, farms	VC	U
Western Tanger (Piranga ludoviciana)	Conifers	C	C
Black-headed Grosbeak (Pheucticus melanocephalus)	Deciduous woods	U	U
Lazuli Bunting (Passerina amoena)	Thickets	U	U
Evening Grosbeak (Hesperiphona vespertina)	Conifers, deciduous woods	R	U
Purple Finch (Carpadacus purpureus)	Conifers, deciduous woods	R	U
Cassin's Finch (Carpadocacus cassinii)	Ponderosa pine, alpine	U	C
House Finch (Carpodacus mexicanus)	Urban, farms	VC	
Pine Grosbeak (Pinicola enucleator)	Brush	O	U
Black Rosy Finch (Leucosticte atrata)	Fields, alpine		U
Pine Siskin (Spinus pinus)	Conifers, mixed woods	U	C
American Goldfinch (Spinus tristis)	Grasslands	U	C
Lesser Goldfinch (Spinus psaltria)	Grasslands	VR	
Red Crossbill (Loxia curvirostra)	Conifers	U	C
Green-tailed Towhee (Chlorura chlorura)	Ponderosa pine, Juniper, Mahogany	U	U
Rufous-sided Towhee (Pipilo erythrophthalmus)	Thickets	U	C
Savannah Sparrow (Passerculus sandwichensis)	Fields, dunes	VC	C
Vesper Sparrow (Pooecetes gramineus)	Fields, farms	U	U
Lark Sparrow (Chodestes grammacus)	Sagebrush, Juniper	U	U
Black-throated Sparrow (Amphispiza bilineata)	Sagebrush, Juniper	U	
Sage Sparrow (Amphispiza belli)	SAgebrush	C	U
Dark-eyed Junco (Junco hyemalis)	Brush, mixed woods, conifers	U	VC
Tree Sparrow (Spizella arborea)	Willows, stream bottoms	R	U
Chipping Sparrow (Spizella passerina)	All open areas	C	U
Brewer's Sparrow (Spizella breweri)	SAgebrush	VC	R
White-crowned Sparrow (Zonotrichia leucophrys)	Willows, open brush	C	U
Golden-crowned Sparrow (Zonotrichia atricapilla)	Weed patches	R	R
White-throated Sparrow (Zonotrichia albicellis)	Open brush thickets	R	R
Fox Sparrow (Passerella iliaca)	Thickets, brush	U	C
Lincoln's Sparrow (Melospiza linocolnii)	Wet meadows, stream bottoms	U	U
Swamp Sparrow (Melospiza geogiana)	Bogs, marshes	H	
Song Sparrow (Mieospiza melodia)	Thickets, brush	VC	VC
Snow Bunting (Plectrophenax nivalis)	Fields, dines	O	O
Lapland Longspur (Calcarius lapponicus)	Thickets of mahogany, juniper	U	U

Amphibians and Reptiles that may be found in the proposed lease areas follow:

		Comments
Salamanders		
Northern Long-toed salamander	(*Ambystoma macrodactylum krausei* *)	Possibly in ponds in Willow Creek drainage in T.22S., R.29E.
Frogs and Toads		
Great Basin spadefoot	(*Scaphiopus intermontanus*)	
Boreal toad	(*Bufo boreas boreas*)	
Pacific treefrog	(*Hyla regilla*)	
Spotted frog	(*Rana pretiosa*)	Areas with permanent water
Lizards		
Great Basin whiptail	(*Cnemidophorus tigris tigris*)	Diamond Craters
Great Bsin fence lizard	(*Sceloporus occidentalis biseriatus*)	
Northern Sagebrush lizard	(*Sceloporus graciosus graciosus*)	
Northern side-blotched lizard	(*Uta stansburiana stansburiana*)	
Short-horned lizard	(*Phrynosoma douglassi*)	
Western skink	(*Eubeces skiltonianus skiltonianus*)	
Desert horned lizard	(*Phrynosoma platyrhines*)	
Snakes		
Rocky Mountain rubber boa	(*Charina bottae utahensis*)	Moist areas
Western yellow-bellied racer	(*Coluber constrictor mormon*)	
Desert striped whipsnake	(*Masticophis taeniatus taeniatus*)	
Great Basin gopher snake	(*Pituophis melanoleucus deserticola*)	
Valley garter snake	(*Thamnophis sirtalis fitchi*)	
Wandering garter snake	(*Thamnophis elegans vagrans*)	
Western rattlesnake	(*Crotalus viridis lutosus* and intergrades with *C. v. oreganus*)	
Possible, but not likely		
Longnosed leopard lizard	(*Crotaphytus wislizeni wislizeni*)	
Western ground snake	(*Sonora semiannulata*)	
Desert night snake	(*Hypsiglena torquata deserticola*)	

*Toxonomy after Stebbins.

Mammals that may be found in the proposed lease areas follow:

Common Name	Scientific Name	High Desert	Conifer
Mule Deer	(Odocoileus hemionus)	X	X
Pronghorn Antelope	(Antilocapro americana)	X	
Rocky Mtn. Elk	(Cervus canadensis)		X
Rocky Mtn. Shrew	(Sorex vagrans)	X	
Malheur Shrew	(Sorex preblei	?	
Masked Shrew	(Sorex cinereus)	X	
Water Shrew	(Sorex palustris)	X	
Western Pipistrelle	(Pipistrellus hesperus)	X	
Little Brown Bat	(Myotis lucifugus)	X	
Fringed Brown Bat	(Myotis thysanodes)	X	
Western Brown Bat	(Myotis volans)	X	
California Brown Bat	(Myotis Californicus)	X	
Masked Brown Bat	(Myotis subulatus)	X	
Big Brown Bat	(Eptesicus fuscus)	X	
Hoary Bat	(Lasiurus cinereus)	X	
Pallid Bat	(Antrozous pallidus)	X	
Big Freetail Bat	(Tadarida malossa)	X	
Silver-haired Bat	(Lasionycteris moctivagons)	X	
Yuma Myotis	(Myotis yumonensis)	X	
Western Big Earred Bat	(Plecotus townsendi)	X	
Long-earred Myotis	(Myotis eyotis)	X	
Balck-tailed Jackrabbit	(Lepus californicus)	X	
Pigmy Rabbit	(Sylvilagus idahoensis)	X	
Mountain Cottontail	(Sylvilagus nuttali)	X	
Yellow-bellied Marmot	(Marmota flaviventris)	X	
Belding Ground Squirrel	(Citellus beldingi)	X	
Townsend Ground Squirrel	(Citellus townsendi)	X	
White-tailed Antelope Squirrel	(Ammospermeprilus levcurus)	X	
Golden Mantled Ground Squirrel	(Citellus latcralis)	X	X
Least Chipmunk	(Eutamias minimus)	X	
Yellow Pine Chipmunk	(Eutamias amoenus)		X
Northern Pocket Gopher	(Thomomys talpoide)	X	
Great Basin Pocket Mouse	(Perognathus parvus)	X	
Great Basin Kangaroo Rat	(Dipodomys microps)	X	

Common Name	Scientific Name	High Desert	Conifer
Northern Grasshopper Mouse	(*Onychomys leucogaster*)	X	
Western Jumping Mouse	(*Zapus princeps*)	X	
Ord's Kangaroo Rat	(*Dipodomus ordi*)	X	
Beaver	(*Castor canadensis*)	X	
Western Harvest Mouse	(*Reithrodontomys megalotis*)	X	
Canyon Mouse	(*Peromyscus crinitus*)	X	
Deer Mouse	(*Peromyscus maniculatus*)	X	X
Pinyon Mouse	(*Peromyscus truei*)	X	
Desert Packrat	(*Neotoma lepida*)	X	
Bushy Tailed Packrat	(*Neotoma cinera*)	X	X
Mountain Vole	(*Microtus montanus*)	X	
Sagebrush Vole	(*Lagurus curtatus*)	X	
Longtail Vole	(*Micratus longicaudus*)		X
Porcupine	(*Erethizon dorsatum*)	X	X
Black Bear	(*Ursus americanus*)		X
Raccoon	(*Procyon lotar*)	X	X
Long-tailed Weasel	(*Mustela frenata*)		X
Mink	(*Mustela vision*)		?
Coyote	(*Canis latrans*)	X	X
Badger	(*Taxidea caxus*)	X	X
Common Striped Skunk	(*Mephitis maphitis*)	?	?
Western Spotted Skunk	(*Spilogale gracilis*)	X	X
Mountain Lion	(*Felis concolor*)	X	X
Bobcat	(*Lynx rufus*)	X	X

X - Denotes usual ranges